Constructionist Approaches to Emotion in Psychology and Related Fields

Lisa Feldman Barrett[1,2,3]

and

Tsiona Lida[4]

[1]Department of Psychology, Northeastern University, Boston, MA.

[2]Athinoula A. Martinos Center for Biomedical Imaging

[3]Psychiatric Neuroimaging Division, Department of Psychiatry, Massachusetts General Hospital and Harvard Medical School, Charlestown, MA

[4]Department of History, Harvard University

Corresponding author: l.barrett@northeastern.edu

Lisa Feldman Barrett is a university distinguished professor at Northeastern University with appointments at the Massachusetts General Hospital (MGH) and Harvard Medical School, where she co-directs the Interdisciplinary Affective Science Laboratory (IASLab). She is the author of *How Emotions Are Made: The Secret Life of the Brain* and *Seven and a Half Lessons About the Brain*. She is among the top 1% most-cited scientists for her research in psychology and neuroscience.

Tsiona Lida is a doctoral student in history at Harvard University and a research affiliate of the IASLab. She studies affect and emotion in the context of modern European intellectual history and Jewish history.

Abstract

This chapter begins by drawing together various historical threads of the constructionist perspective. We then review selected findings that serve as background assumptions for the theory of constructed emotion, a multidisciplinary framework of conceptual tools and empirical strategies for investigating brain, body, mind, and behavior; the theory of constructed emotion provides a common set of hypotheses to integrate the construction of emotion with the construction of other psychological phenomena, such as memory, perception, and behavior. What follows are three sections, each of which briefly covers one core constructionist hypothesis. We then briefly discuss common misunderstandings and mischaracterizations of the constructionist perspective. We end with a selection of questions about the nature of emotion that might be clarified and made more empirically tractable by a better understanding of the constructionist perspective.

Introduction

According to the historian of science Naomi Oreskes (Oreskes, 2019), the validity of science rests on the consensus of scientists from diverse backgrounds. Do they agree on which hypotheses are most important to test, which observations provide the best tests for those hypotheses, which interpretations of the observations are most defensible, and which hypotheses are most supported vs. those which are most in doubt? From this vantage point, the science of emotion has a serious validity problem. The linguist George Lakoff called emotion an *essentially contested concept* (Lakoff, 2016): scientists agree that emotions should be studied, but after about 150 years of scholarly activity, that is about all we agree on. This situation is not easily remedied. Scientists who take different theoretical approaches also have different ontological assumptions (Barrett, 2015), leading them to consistently misunderstand one another, even to the point of mischaracterizing each other's hypotheses in the most fundamental ways. At times scientists can't agree on the specific experiments that might resolve their debates, in part because they disagree on what they are actually debating about. Attempts to summarize relevant research often do so selectively, sometimes failing to grapple with evidence that precisely calls their preferred hypotheses into question. There are notable exceptions, of course, but overall, the science of emotion remains mired in a scientific stalemate: Research progresses in silos, compromising the accumulation of knowledge, and an emerging consensus is nowhere in sight. One necessary start for resolving this impasse, at a minimum, is to ensure that scientists develop an accurate understanding of the various assumptions, hypotheses, and methods that constitute these debates, particularly as they evolve in response to new research findings and conceptual advances.

With these concerns in mind, this chapter summarizes one theoretical perspective in this unending deadlock — a “constructionist” perspective on the nature of emotion. In the psychological science, there is broad scientific consensus that instances of memory and perception are constructed, situated brain events, emerging dynamically from the interplay of more basic ingredients, rather than being triggered as irreducible, biologically prepared states with separate, dedicated mechanisms. Recent evidence suggests that even behaviors are constructed in a flexible, situated manner out of more basic elements (Datta, 2019). A constructionist approach to the science of emotion hypothesizes something similar about instances of emotion. A constructionist perspective is contrasted with a *typological perspective* (see Table 1). A typology groups instances, events, or objects with similar features or qualities into clusters. The groupings (i.e., types) can have firm boundaries and contain instances that share necessary and sufficient features (i.e., natural kind categories) or can have fuzzy boundaries and contain instances that vary somewhat in their features, but that bear a family resemblance to a representative instance or a typical instance (i.e., prototype categories). A typological perspective to the study of emotion assumes that there is a universal taxonomy of emotion categories and empirically searches for the features that define each category as a biologically and psychologically distinct type. Examples of typological approaches are basic emotion and discrete emotion approaches, such as causal appraisal approaches and some functional approaches (e.g., Cowen and Keltner, 2021; Ekman and Cordaro, 2011; Izard, 1977; Lazarus, 2001, 1991; Panksepp, 1998; Roseman, 2011; Scherer, 2001); for historical references, see Gendron and Barrett (2009) and references therein; also see <see references, this volume>).

Chapter Overview

This chapter begins by drawing together various historical threads of the constructionist perspective. Next, we review selected findings that serve as background assumptions for a constructionist approach to emotion. What follows are three sections, each of which briefly covers one core constructionist hypothesis. We then briefly discuss common misunderstandings and mischaracterizations of the constructionist perspective. We end with a selection of questions about the nature of emotion that might be clarified and made more empirically tractable by a better understanding of the differences between constructionist and typological perspectives.

We should point out that our goal with this chapter is not a comprehensive review of the constructionist perspective. It is a sketch that serves as a roadmap for those who are interested and motivated to delve into to published works for details on constructionist approaches and their relation to published empirical findings. Such efforts are necessary to begin to untangle the web of debates that currently burden the science of emotion, hopefully setting the stage for future research and dialogue that, in principle, allows a scientific consensus about the nature of emotion to eventually emerge. (Note: several of the topics covered in this chapter are associated with large, published literatures and as such, comprehensive referencing was not possible; to address this issue, on occasion we refer to published papers from our lab that contain relevant references from other labs, also referring the reader to "references therein").

Brief History of Constructionist Approaches

The psychologist George Mandler first named constructionism as an approach to the science of emotion in his 1984 book, *Mind and Body: Psychology of Emotion and Stress* (in a section titled "The Construction of Emotion"; Mandler, 1984; see also Mandler, 1990), but nascent constructionist ideas can be easily traced back from early to mid-20th century to the 19th century, with historical tendrils reaching back even further (Barrett, 2017a; Gendron and Barrett, 2009). In the modern era, a constructionist perspective to emotion was synonymous with social constructionist views for many years until psychological construction was introduced in 2003 by the psychologist James Russell (Russell, 2003). In a social construction view, instances of emotion are hypothesized to derive from social and cultural ingredients (i.e., cultural artifacts), including social roles, beliefs, values, other people's actions towards you, and various sociocultural structures (e.g., Averill, 1980; Boiger and Mesquita, 2012; Harre, 1986 <see chapters, this volume>; for a historical and anthropological overview of social constructionism, see Reddy, 1997). Psychological construction views propose that the ingredients of emotion are psychological processes: emotional instances are hypothesized to arise from affective feelings when they are categorized, conceptualized, or otherwise made meaningful as emotions with a mental mechanism (e.g., Cunningham et al., 2013; Lindquist, 2013; Mandler, 1984; Russell, 2003; also see Barrett and Russell, 2015).

One constructionist approach, called the conceptual act theory, integrated psychological and social construction hypotheses to propose that the human mind transforms feelings of affect into instances of emotion by categorizing them with situation-specific, embodied emotion concepts (e.g., Barrett, 2006; Barrett Mesquita et al., 2007; Barrett et al., 2007; Barrett, 2012). The conceptual act theory was crafted as an interdisciplinary approach, incorporating findings and insights from cognitive science (e.g., the study of grounded cognition, concepts and categories), from social psychology, from anthropology (e.g., Bateson and Mead, 1942; see Mesquita and Frijda, 1992; Russell, 1991a and references therein) and linguistics (e.g., Pavlenko, 2014; Vigliocco et al., 2009).

Since the first paper on the conceptual act theory in 2006, our lab's constructionist approach has continued to evolve under the influence of research and conceptual tools from a variety of scholarly fields; our approach is a work under construction, if you will. The result was a major shift in scientific approach that gave rise to *the theory of constructed emotion* (Barrett, 2017a; Barrett, 2017b), and eventually to the constructed mind approach (Barrett, 2009; Shaffer et al., 2022). It is a multidisciplinary framework of conceptual tools and empirical strategies for investigating brain, body, mind, and behavior, providing a common set of hypotheses to integrate the construction of emotion with the construction of other psychological phenomena, such as memory, perception, and behavior. The constructed mind approach attempts to understand how mental events and associated behavior arise within a brain that is in continual, dynamic conversation with its body and the surrounding world, including the social world.

In this chapter, we will focus on the hypotheses that are most relevant for the construction of emotion (i.e., the theory of constructed emotion). The scholarly domains that are relevant to our hypotheses include:

- Neuroscience investigations of structural and functional brain architectures (see these papers from our lab and references therein: (Barrett and Satpute, 2013; Katsumi et al., 2021a; Kleckner et al., 2017; Raz et al., 2016; van den Heuvel et al., 2016; Zhang et al., 2019, 2020), including the evolution and embryological development the vertebrate nervous system (e.g., Cisek, 2019a; Gee, 2018; Striedter, 2005; Striedter and Northcutt, 2020).
- Neuroconstruction (e.g., Karmiloff-Smith et al., 1995; Mareschal et al., 2007; Westermann et al., 2007), as well as evidence from developmental science, including research on rational constructivism (e.g., Xu and Kushnir, 2013), infant brain development (from our lab see Atzil et al., 2018 and references therein), and the developmental cascades that support motor and cognitive development (e.g., Oakes and Rakison, 2019). For hypotheses related to the

development of emotion knowledge, see Hoemann et al., 2019b, 2020b and references therein).

- Comparative neuroscience, evolutionary robotics, and behavioral ecology (from our lab, see these works and references therein: (Barrett, 2020; Lisa Feldman Barrett et al., 2007; Barrett and Finlay, 2018; also see Anderson and Finlay, 2014; Finlay and Uchiyama, 2015, 2015; MacIver and Finlay, 2021.
- Signal processing and brain metabolics (from our lab, see these papers and references therein: (Theriault et al., 2021a, 2021b; also see Sterling and Laughlin, 2015).
- Predictive processing approaches to brain function (from our lab, see these papers and references therein: (Barrett, 2017b; Barrett and Simmons, 2015; Chanes and Barrett, 2016; Hutchinson and Barrett, 2019; Katsumi et al., 2021b; Kleckner et al., 2017; also see ∂Clark, 2013; Friston et al., 2017; Hohwy and Seth, 2020; McNamee and Wolpert, 2019; Owens et al., 2018; Petzschner et al., 2021; Pezzulo et al., 2021, 2015; Quigley et al., 2021; Schulkin and Sterling, 2019; Seth and Friston, 2016; Seth and Tsakiris, 2018; Stephan et al., 2016).
- Evidence from systems physiology, such as the predictive regulation of the autonomic nervous system, immune system, endocrine system, and other systems of the body (i.e., allostasis Sterling, 2012), as well as heterarchical control in physiological function (e.g., Bechtel and Bich, 2021; Sennesh et al., 2021).
- Findings and hypotheses from the extended evolutionary synthesis, including cultural inheritance, cultural evolution and gene-culture co-evolution (from our lab, see these works and references therein: Barrett, 2017a; Gendron et al., 2020b).
- Concepts from dynamical systems theory, state space modeling and complex adaptive systems, particularly as applied to nervous system function.

- Insights from the history of emotions that enhance an understanding of emotion concepts that are conditioned by cultural and historical contexts (e.g., Biess and Gross, 2014; Boddice, 2019; Frevert et al., 2014; Ngai, 2007; Reddy, 1997), from the history of the science of emotion (e.g., Dror, 2017), and the philosophy of science (e.g., Golinski, 2005; Hacking, 1983), including natural constructivism (e.g., Gleiser, 2015), as well as various philosophical works in the domains of biology and neuroscience (e.g., Anderson, 2014; Bechtel and Bich, 2021; Godfrey-Smith, 2017; Jékely et al., 2015; Mayr, 2004; Winning and Bechtel, 2018).

Most scholarship in the science of emotion is rooted in some version of a Linnaean-type taxonomy of emotion categories. Our approach, in contrast, begins with the most up-to-date understanding of human nervous system evolution, development, structure, and function, and asks how a human brain with certain computational capacities creates instances of emotion as it continuously converses with its body and the elements of its environmental niche (which is physical, social, cultural, and historical) in the service of efficient energy regulation. The empirical emphasis is on *observing and modeling structured variation* in emotional responding across situations, people, and cultures. Historically, observations of variation were embedded in critiques of typological approaches, beginning with William James (James, 1998, 1994, 1884) onward (e.g., Dashiell, 1928; Duffy, 1941, 1934a, 1934b; Dunlap, 1932; Harlow and Stagner, 1933, 1932; Hunt, 1941; Landis, 1924; Sherman, 1927a, 1927b).

Understanding instances of emotion as perceptions is, perhaps, one of the oldest ideas in psychology (e.g., Descartes, 1989; Malebranche, 1997; Spinoza, 1927). In our constructionist approach, instances of emotion, like all mental events, are hypothesized to emerge in a brain as it continually creates the features of experience in the service of efficient energy regulation and action planning (e.g., Barrett, 2017a, b; Barrett, in press); in this view, actions include both skeletomotor movements of the body and visceromotor movements inside the body). This continual coordination and construction is hypothesized to be process by which incoming sensory signals become psychologically meaningful.

Historically, this domain-general "meaning making" process has been described by a variety of related concepts: conceptualization (e.g., Dharmakirti, as discussed in (Dreyfus and Thompson, 2007; Kant, 1929), inferences (e.g., Alhazen ca 1030, cited in (Hohwy, 2013); Helmholtz), interpretations (e.g., Duffy, 1941), ideas (Wundt, 1998), internal models (Craik, 1944; Johnson-Laird, 1983), cognitive maps (e.g., Tolman, 1948), the re-assembling of memories from similar past experiences, prior knowledge, or hypotheses (e.g., Bruner, 1990; Gregory, 1980; Neisser, 1967; Sokolov, 1963), social affiliation (Schachter, 1959; Schachter and Singer, 1962), and the social meaning of situations (e.g., Dashiell, 1928; Dunlap, 1932; Landis, 1924; Sherman, 1927a). (For other historical discussions of meaning-making processes that produce instances of emotion, see Harlow and Stagner, 1933, 1932; Hunt, 1941; Mandler, 1990, 1984). More recent meaning-making has been described as a combination of attribution and categorization with emotion prototypes (Russell, 2003) or abstraction over time (Cunningham et al., 2013). Our constructionist approach refers to meaning making variously, depending on the aspects we are emphasizing, as "categorizing signals with ad hoc concepts that are constructed in a situation-specific manner," "running an internal model of the body in the world," "embodied simulation," "predictive processing," "allostasis," "perceptual inference," "generalization," or just "memory." We integrate these, and other similar constructs, such as "causal inference" (Lochmann and Deneve, 2011) and notions of "latent cause inference" (Gershman et al., 2010), into a conceptual framework. In this updated view, *instances of emotion do not arise from categorizing affect*. Valence, arousal, and other properties of affect are *not ingredients* of meaning-making, but are understood to be abstract, mental features that the brain computes *during* meaning-making.

Background

Several distinctions and background findings are required to properly understand the theory of constructed emotion and its unique character. We mention five of them here. These insights also illuminate how the theory of constructed emotion differs from most typological approaches (for others, see Barrett, 2015; Barrett, 2017a,b).

First, references to “an emotion” in the scientific literature typically are ambiguous because they don’t distinguish between a *category* of emotion (i.e., a group of similar instances) and an *instance* of that category. The word “anger,” for example, might be used to refer to a specific instance of anger for a specific individual in a specific situation, or to many instances across individuals and situations. This ambiguity has led to profound misunderstandings in the science of emotion, starting with William James (who used the same phrase for both meanings, which set the stage for the ill-considered James-Lange theory of emotion; for discussion, see Barrett, 2017a). In cognitive science, a category is simply any group of instances (e.g., objects, organisms, or events) that share similar features (i.e., features that make the instances equivalent); categorization is the process of grouping instances as similar (Murphy, 2002) on the basis of one or more features that are deemed to be equivalent across those instances (i.e., based on *features of equivalence*). An *instance* of anger, for example, is a specific event for a specific person in a specific spatio-temporal context; the *category* anger is a grouping of instances that share features to some extent. Any given instance of emotion can be described as having *physical features*, such as the physiological changes that support certain skeletomotor and postural movements, the movements themselves, vocal acoustics, chemical changes, patterns of neural firing in the brain, and so on. Instances also have *mental features*, for example, goals (e.g., to avoid harm), affect (valence, arousal, etc.), appraisals (descriptions of how the situation is experienced, such as novel vs. familiar, threatening vs. safe), motivation (effort, fatigue, value, reward, etc.), words, and so on (for a discussion, see Hoemann et al., 2020; Adolphs et al. 2019).

Second, a grouping of instances can be similar because they share physical features and/or mental features. Instances that share physical features (i.e., a single feature or a pattern of features) are called concrete categories or *perceptual categories*. For example, apples tend to be round, small enough to grasp in a human hand, contain light-colored flesh, crunch when you bite them, and raise your blood sugar upon eating. Instances that share mental features, but whose physical features vary from one another, are variously referred to *abstract, conceptual, or functional categories*. For example, 'food' is an abstract category because the distinction between edible and nonedible is based on the function of satisfying hunger in a culturally appropriate way (e.g., grasshoppers are eaten as food in some situations but are killed as pests in others). Moreover, the same object or event can be categorized in a flexible, situated manner: a bright yellow dandelion with green leaves might be considered food (e.g., in a salad), a weed (e.g., in the garden to be plucked and thrown away), or a flower (e.g., in a bouquet of wildflowers), *depending on the individual's goal in a particular situation*. Even instances with similar physical features (i.e., concrete, perceptual categories) can be categorized in an abstract way. For example, apples can be grouped in different ways depending on whether their function in a given situation is for snacking, such as Fuji or Gala apples, for baking a pie, such as Cortland or Granny Smith apples, or for target practice, such as anything lying around the yard (e.g., see Barsalou, 1983).

Third, abstract, conceptual categories are ubiquitous and easy to mistake for perceptual categories. A facial movement, such as scowling, is an abstract category because movements that look identical to the naked eye are variable under the skin, i.e., scowls are created by physical changes that differ across people because of individual differences in facial anatomy (see Barrett et al., 2019, Supplementary Online Materials, Box 5 and references therein). Similarly, the same action can vary within one individual across instances because of varied execution at the muscular level (for a discussion of action concepts, see Barrett & Finlay, 2018; this is similar to the notion of “policies” in reinforcement learning). A scent is an abstract category (e.g., different chemicals bind to the same olfactory receptors to create the same smell, i.e., they have the same function; Cleland and Borthakur, 2020). Phonemes are also abstract categories (e.g., The sound of a “b” in the words “bad” and “bed” is acoustically different to a human perceiver but serves the same phonematic function; Barsalou, 1992). Even bird, cats, flowers, weeds, and other categories that are assumed to be concrete and perceptual can, in fact, be understood as abstract, conceptual categories (for discussion, see Barrett, 2012, 2017a). Creating such categories (i.e., groupings of instances whose similarity is functional but have varied physical features) is a fundamental human capacity that is present early in infancy and arises in all domains of human life (see Hoemann et al., 2020 and references therein).

Fourth, the ability to form categories is pervasive in the animal kingdom (Mareschal et al., 2010), from single cell animals like bacteria (e.g., Freddolino and Tavazoie, 2012; Lyon, 2015) to multi-cellular animals, like humans. Categories are necessary for managing uncertainty (in the meaning of sensory signals) and planning action. Categorization is a species-general ability. The nature of the categories is dependent on the computational capacities of its brain as well as the nature of its body and its ecological niche.

Fifth, a pattern of features that describes an instance of emotion (or cognition, perception, or any other psychological event) is *an ensemble of interwoven physical signals*. Some of these physical signals are found *outside the brain*, in an animal's body and niche (what scientists refer to as "context," "stimuli," or "reactions"); these can include changes in cardiovascular response, respiratory response, chemical and hormonal changes, energetic changes, etc. (collectively referred to as visceromotor movements), as well as skeletomotor movements in the face, body and vocal tract, vocal acoustics, and so on. Some of the relevant physical signals also are found *inside a brain*. These include action potentials and chemical signals that assemble features that are closer in detail to the raw sense data coming from the sensory surfaces of the body, and that coordinate and regulate organ function, metabolism, immune function, and muscle fiber contractions. These signals are compressed along various compression gradients in the brain (as discussed in Barrett, 2017b; Katsumi et al., 2021a, 2021b) to construct multimodal summaries that create the abstract mental features we mentioned earlier, such as "goal," "value," "threat," "reward," "valence," "arousal," and "novelty" (i.e., mental features are compressed, multi-modal summaries of the higher-dimensional sensory and motor signals; for discussion, see Barrett, 2017a, b; Barrett & Finlay, 2018; Katsumi et al., 2021a). An important insight here is that the some of the physical signals that are important to creating any psychological event, including instances of emotion, reside within a brain as it generalizes from the past to the present (i.e., as the brain constructs features of equivalence; for discussion, see Barrett, 2017a,b). These features of equivalence are the means by which a brain generalizes from the past to regulate the internal systems of the body, guide action, and create experience in the present, thereby giving psychological meaning to sensory and motor signals. The result is what the neuroscientist Gerald Edelman referred to as "the remembered present" (Edelman, 1989).

Hypothesis 1: Conceptual Categories and Relational Meaning

A guiding principle of the theory of constructed emotion is that a brain must navigate its body through a highly variable and only partly predictable world, and that, from a brain's perspective, physical signals in the world and in the body are inherently ambiguous. Via the sensory surfaces of the body, the brain receives sensory signals, but these signals are the *outcomes* of causes. The brain does not have access to the causes. A brain must reduce this uncertainty to effectively plan and coordinate action, including actions within the body, i.e., visceromotor actions) and actions of the body (i.e., skeletomotor actions). This *inverse inference* problem, from outcomes to causes, must be solved in a metabolically efficient manner (Sterling & Laughlin, 2015). To do so, a brain *generalizes from past events* that it infers are similar to the current circumstances (Radulescu et al., 2021), i.e., the current state of the body and the world, according to some notion of equivalence. By "generalizes," we mean that a brain reassembles features from those past events (i.e., it constructs features of equivalence). In doing so, a brain reassembles a *category* of past events (i.e., a group of similar instances that share features of equivalence) in order to coordinate and control motor actions, thereby explaining the cause of those actions and associated sensory signals (Barrett, 2017a,b and references therein). We hypothesize that this is how all physical actions and sensory signals become psychologically meaningful.

Categories are Constructed Predictively

When a brain reassembles past events that are similar to the present, in effect, it is constructing categories that contain possible futures, i.e., possible plans for action and for disambiguating the meaning of sensory signals. The theory of constructed emotion hypothesizes that category construction, which occurs automatically and continuously through an individual's life, proceeds via prediction, selection and correction, together known as predictive processing (for discussion and evidence, see these papers and references therein (Barrett, 2017b; Barrett and Simmons, 2015; Chanes and Barrett, 2016; Hutchinson and Barrett, 2019; Katsumi et al., 2021a, 2021b). Each psychological event begins as a category, constructed as an ensemble of interrelated, temporally evolving physical signals that are assembled across the entire brain. These signals, which the literature refers to as "prediction signals," "simulation," or simply "memory," constitute patterns of possible features. The brain continually checks these prediction signals against ongoing signals from the body's sensory surfaces (relaying information about the state of the body and the state of the world). Incoming sensory signals, along with attentional signals called "precision signals," help to select the pattern of signals (of features) that a brain will select as coordinated motor actions and conscious experience. The incoming signals and the signals that control motor actions are said to be categorized, and the features of equivalence are said to explain action and their associated sensations. When there are unexpected signals from the sensory surfaces, or expected signals do not materialize, collectively called "prediction errors," a brain has an opportunity to correct its predictions (known as "learning"). Predictive processing, when understood as continuous category construction, offers a coherent, neurobiological research framework to unify many proposed constructs for how a brain creates relational meaning, such as appraisal, construal, generalization, memory, perceptual inference, conceptualization, simulation, causal inference, latent cause inference, and categorization.

Category Construction is Situated

To reduce ambiguity and create meaning in a metabolically efficient way, category construction must be tailored to particular signals in the environment when the body is in a particular state. Accordingly, we hypothesize that a brain constructs *ad hoc or situated* *categories* (for more on ad hoc categories, see Barrett, 2017a,b; Barsalou, 1983; Barsalou et al., 2003; Casasanto and Lupyan, 2015). By continually constructing features of equivalence (i.e., reassembling bits of past experience that are similar in some way to the present), a brain continually runs an internal model to estimate the state of its body in the surrounding world, a model that plans and gives meaning to motor signals and their associated sensory consequences. By continually assembling complex ensembles of signals, including features of equivalence (i.e., similarities to past events), the brain's internal model can be described as continually constructing *situated categories*, such as an emotion category tailored to the goals and functional requirements of the present situation. By implication, then, every emotion category implemented in any human brain is a *situated event* (for more on the view of conceptualization as a process, see Barsalou, 1987; Barsalou et al., 2010; Casasanto and Lupyan, 2015; Spivey, 2007). Its features of equivalence are always constructed in a particular perceiver for a particular function in a particular situation.

Emotion Categories are Abstract, Situated Categories

The theory of constructed emotion hypothesizes that all animal brains construct situated categories to guide action and give meaning to sensory signals. The nature of the constructed categories depends on whether the features of equivalence are low-level sensory and motor features or compressed, multi-modal summaries, i.e., abstract mental features. If the features of equivalence are mental features, then the brain is constructing *abstract, conceptual categories*. The ability to construct such categories is determined by the degree of abstraction that a brain can support — namely, the degree of *compression* in the features that are constructed, not the computational principles that govern their construction. These differences result from general brain-scaling functions (Workman et al., 2013) and information from an animal's niche. For example, the human brain has expanded association cortices in the frontal lobes, parietal cortex, and inferotemporal cortex compared to other primates, including other great apes (Sherwood et al., 2017, 2012), along with metabolic and neuropil changes in the upper layers of cortex (see Theriault et al., 2021a and references therein). This expansion potentially allows for increased information compression and dimensionality reduction, suggesting that human brains are capable of assembling multimodal summaries (i.e., features) characterized by greater abstraction (see Finlay and Uchiyama, 2015; Katsumi et al., 2021a).

The theory of constructed emotion hypothesizes that when a brain reassembles features from past instances of emotion to guide action and give sensory signals meaning, it is, in effect, *constructing a situated, conceptual category for emotion*, with multimodal, compressed summaries that categorize the other physical signals, giving them emotional meaning and rendering the entire event an instance of that emotion category. In this view, an emotion category is always constructed in a specific situation by a specific person to serve a particular function or goal, i.e., every emotion category is an *ad hoc, situated, conceptual category*. This hypothesis obviously has important implications for how to generalize scientific findings from non-human animals to humans (for a discussion, see Barrett, in press).

An emotion category, then, is a whole brain event that begins as abstract mental features of equivalence. These features contain plans for visceromotor and motor action (i.e., abstract action concepts; Barrett & Finlay, 2018), the value of those actions, appraisals of the situation, affective properties, and so on. We hypothesize that these signals become more detailed and particularized as they cascade down through the brainstem to spinal cord, and along the primary cytoarchitectural gradient of the cerebral cortex to the primary sensory areas that receive sense data from the thalamus and sensory surfaces of the body (Chanes & Barrett, 2016; Katsumi, Theriault et al., 2021; Zhang et al., 2019). As an emotion category, this ensemble of signals is a set of predictions about the potential causes of predicted motor actions and predicted sensory inputs to the brain, and the potential meaning of those inputs via their relationship to the pattern of abstract mental features and predicted motor plan (for neural details, see these papers and references therein (Barrett, 2017a,b; Barrett & Simmons, 2015; Chanes & Barrett, 2016; Hutchinson & Barrett, 2019; Katsumi, Kamona, et al., 2021; Katsumi, Theriault, et al., 2021).

Category Construction is in the Service of Coordinating and Regulating Bodily Systems

The theory of constructed emotion assumes that psychological meaning is rooted, fundamentally, in the brain's predictive regulation of the body (for a discussion of some of the neuroscience details, see e.g., Barrett, 2017b; Kleckner et al., 2017). The brain's internal model is ultimately in the service of that central mission so an animal can grow, survive, and ultimately reproduce. Growth, survival, and reproduction (and therefore gene transmission) require a continual intake and expenditure of metabolic and other biological resources. This balancing act is called "allostasis" (Sterling, 2012) and translates into evolutionary fitness of a species. "At its biological core, life is a game of turning energy into offspring" (Pontzer, 2015: 170). Metabolic efficiency increases evolutionary fitness, both by increasing surplus energy available for mating and caring for offspring, and by decreasing the frequency with which an organism must seek nutrients and expose itself to predators (Pontzer, 2015; Simpson and Raubenheimer, 2012).

This hypothesis, that the features of movement and experience are constructed in the service of efficient energy regulation, is consistent with evolutionary approaches to understanding nervous system function, in which the fundamental function of a brain is not to build knowledge about the world, but to control an animal's energetic state as it navigates its niche (e.g., Cisek, 2019, 2021) and with evidence that certain mental features, such as affect and motivation for movement, are associated with metabolic inefficiencies (see Shaffer et al., 2022 and references therein). From this perspective, every situated category, such as an ad hoc category for fear, begins as abstract, mental features that include an abstract action concept or intention — a descending cascade of potential motor patterns to control the systems within the body (e.g., the autonomic nervous system, immune system, endocrine system, etc.) that support movements of the body (i.e., the skeletomotor system).

Action Creates Experience

The dynamics of predictive processing suggest that action preparation gives rise to experience, not the other way around. During conceptual category construction, prediction signals that prepare motor action simultaneously cascade to simulate the expected sensory consequences of the expected motor movements (called an efference copy or corollary discharge). This hypothesis runs counter to typological views, which hypothesize that a brain detects events in the world and constructs a perception, then evaluates the perception to create a cognition or emotion or some interaction of the two, which then results in an action plan. We propose instead that perception and experience arise *from* predicted actions, rather than causing those actions, and experiences and actions are always constructed with respect to predicted future energy (allostatic) needs. In this view, appraisals are not cognitive mechanisms that cause instances of emotion; they are features that describe how an individual experiences themselves in the immediate situation, consistent with descriptive appraisal views (e.g., Clore and Ortony, 2013, 2008), and they are constructed in the process of categorization (for discussion, see Barrett, Mesquita et al., 2007).

Physical Signals Have Relational Meaning

If hypothesis 1 is correct, then the particular physical features that occur during a particular instance of emotion, such as changes in peripheral physiology, vocalizations, facial movements, and so on, have no inherent, biologically prepared emotional meaning. Physical features are *made* meaningful as an instance of emotion because a brain predicts that, in the present situation, these *features are functionally similar to past instances of a given emotion category*. That is, physical features acquire meaning *in relation* to past events, as instantiated within the ensemble of biological signals that a brain is re-assembling. For example, smiling can be made meaningful as an expression of anger designed to intimidate, because the action of smiling has some probability of serving this function based on similar situations in the past. Accordingly, emotional meaning does not reside in physical features themselves. The goals, value, affect, and other mental features that give physical features their functionality do not exist in world or on the body. They exist only in the brain that created the signal ensembles.

Even the electrical activity in a population of neurons has no necessary emotional meaning or inherent emotional function. The meaning of any firing neuron is always in relation to other physical signals in the brain (e.g., McIntosh, 2004), most especially the other neurons receiving that neuron's action potential. For example, when a single pattern of action potentials from a single neuron is received by a motor neuron, it is considered a motor signal; when the same action potentials from the same neurons are received by sensory neurons, they are considered sensory signals.

In a human brain, instances of the same category need not have similar sensory and motor features (i.e., instances of anger need not involve the same changes in blood pressure, respiration, physical actions) because the features of equivalence that make the instances similar in a particular situation are abstract, mental features (i.e., the compressed, multi-modal summaries). A single abstract mental feature, or a single pattern of abstract features, can be associated with variable sensory and motor features for controlling the body and creating experience (i.e., with an entire distribution of possible neural assemblies that we refer to as a situated category). These variable patterns of sensory and motor features each have some probability of fitting the present situation (i.e., a prior probability) based on similarity to past experiences that also contained the abstract features of equivalence; that is, by virtue of their shared abstract feature(s), different sensory and motor signals share the same (relational) psychological meaning in a specific situation in the body and the world. The pattern that best matches the high-dimensional details in the situation gives meaning to those sensory and motor signals (i.e., categorizes them). That is, the features of equivalence are the means by which a brain generalizes from past experiences to categorize incoming sensory signals and outgoing motor signals, giving them emotional meaning in a specific situation as a brain regulates the body, guides action, and creates experience.

Summary

Hypothesis 1 of the theory of constructed emotion can be restated thus: every instance of emotion begins as an abstract, situated emotion category. The category contains possible movements and meanings that are assembled from the person's past and are constrained by the sensory signals arriving from the state of the world and the state of the body. The physical features of an instance of emotion have no *inherent, biologically inherited* emotional meaning, but an emotional meaning that is biologically constructed in the moment. Nor does the neural assembly that implements this instance have an inherent, biologically inherited emotional meaning; it creates emotional meaning by the same computational principles that govern the construction of any psychological meaning.

Hypothesis 2: Variation is the Norm

When it comes to emotion, variation is the norm (as discussed in Barrett, 2017a,b; Barrett et al., 2019; Hoemann et al., 2020; Siegel et al., 2018). If instances of emotion emerge as a complex web of physical signals rich in relational meaning, then this predicts a combinatorial explosion in the variety of observable patterns for the instances of any given emotion category, and even for emotion categories across history within a culture or across cultures. In the words of the evolutionary biologist Richard Lewontin, "Organisms are … extremely internally heterogeneous. Their states and motions are consequences of many intersecting causal pathways, and it is unusual that normal variation in any one of these pathways has a strong effect on the outcome…. Indeed, we may define 'normality' as the condition in which no single causal pathway controls the organism… All attempts to understand causes must necessarily involve the observation of variations" (Lewontin, 2000: 93-94).

Variation is Structured

The variation we are discussing is not random; it is structured. It is not unbounded; there are embodiment and ecological constraints. But the variation is considerably greater than what is hypothesized or can be accounted for by a typological perspective on emotion.

Different signals, same emotional meaning. The physical signals that implement a particular array of abstract mental features can be associated with a variety of physical signals that represent the detailed conditions of the body and the outside world. Consider a brain event that corresponds to a particular instance of anger. It begins as a situated, conceptual category for anger — an ensemble of brain-wide signals consisting of possible feature patterns that share a functional feature (or features), allowing an individual to meet a goal in a specific situation, i.e., the events are functionally equivalent for meeting a specific goal in a specific situation. The features of equivalence are functional and in reference to a situated goal. The goal of this instance of anger might be to remove an obstacle, punish someone, win a competition or feel part of a group (e.g., Sinaceur and Tiedens, 2006; Van Kleef and Côté, 2007; Van Zomeren et al., 2004), or even be to avoid harm by attempting to appear powerful (e.g., Ceulemans et al., 2012); Sinaceur and Tidens, 2006). The specific skeletomotor movements that functionally enact a goal (e.g., to run) will depend on the state of the situation and the energetic state of the body (see Barrett & Finlay, 2018 and references therein; also see Cisek, 2021) Accordingly, the person might scowl and shout in anger, cry in anger, freeze in anger, or even laugh in the face of anger — whatever action concept a brain has learned to construct to meet the goal in similar situations. The supporting visceromotor movements that enact the goal can vary and correspondingly the peripheral physiological motif that supports each action will vary accordingly (Obrist, 1981; Obrist et al., 1970). Even the affective features of this instance of anger might vary (e.g., they might be pleasant or unpleasant; (Harmon-Jones and Peterson, 2009). And in principle, the neural signals that construct the instance, which are distributed across the brain and give rise to these varying features, can themselves vary (e.g., see Becker et al., 2012; Guillory and Bujarski, 2014; Herry and Johansen, 2014; Mihov et al., 2013); for discussion, see (Barrett, 2017a,b; Edelman, 1989); this is called degeneracy (a concept we return to in a few paragraphs).

One hypothesis, then, is that *different ensembles of physical signals can share a similar relational emotional meaning* across persons and situations. Studies designed to observe and model structured variation observe it. This is true for facial movements (e.g., Durán and Fernández-Dols, 2021; Gendron et al., 2020a, 2018; Jack et al., 2016; Le Mau et al., 2021; Srinivasan and Martinez, 2021); for discussion and additional references see Barrett et al., 2019); for vocalizations (Hoemann et al., 2019a); for motifs of autonomic nervous system physiology (e.g., see these papers and references therein: Hoemann et al., 2020a; Khalaf et al., 2020; Siegel et al., 2018; Stemmler et al., 2007); even with identical methods and stimuli testing similar samples, for example compare findings from (Kragel and LaBar, 2013) with those from (Stephens et al., 2010)); and for brain activity (Azari et al., 2020; Lebois et al., 2020; Singh et al., 2021; Wilson-Mendenhall et al., 2015, 2011). Even the supposed prototypic brain "biomarkers" for a given emotion category vary substantially across studies (e.g., Horikawa et al., 2020; Kassam et al., 2013; Kragel and Labar, 2015; Saarimaki et al., 2016; Wager et al., 2015; Wilson-Mendenhall et al., 2015; Zhou et al., 2021) and suggest the presence of meaningful, structured variation in the brain basis of emotion.

Studies of non-human animal behaviors associated with emotion likewise find evidence of substantial variation within an emotion category. For example, animals perform many different behaviors that have been defined as "fear" (i.e., that occur in response to threat), each corresponding to different circuitry (e.g., Gross and Canteras, 2012); Faneslow, 2018). Rodents avoid the location of uncertain threat when they are free to move around, such as in a testing chamber with several arms (e.g., Vazdarjanova and McGaugh, 1999), but they continually return to the location when spontaneous movement is observed in a free-roaming situation (e.g., Datta, 2019). When they are not free to move around, rodents freeze (e.g., LeDoux, 2000). When the threat is certain and they cannot escape, rodents respond with defensive aggression — they kick bedding towards the threatening object (e.g., Reynolds and Berridge, 2008) or jump on it and bite (e.g., Blanchard and Blanchard, 1988). And the circuitry that supports defensive aggression towards a cat (a predator) is distinct from that supporting defensive aggression towards another rat (a dominant intruder in the cage; e.g., Motta et al., 2009).

It’s even possible for exactly the same pattern of mental and physical features to be assembled in variable ensembles of neural signals, a phenomenon known as degeneracy or equifinality: a given function can be achieved by structurally distinct mechanisms in different situations. Degeneracy is ubiquitous in biological systems (see Edelman and Gally, 2001; Tononi et al., 1999). For example, different proteins can catalyze the same reaction of enzymes, different antibodies can bind to the same antigen, and different genotypes can produce the same phenotype. In a brain, different neurons give rise to the same intrinsic network (e.g., Marder and Taylor, 2011; Tononi et al., 1998), and different patterns of network interaction can give rise to the same behavior (Price & Friston, 2002). In animal species that have been engineered to knock out selected genes, up to 30% of individuals continue to show the phenotype despite the absence of the selected genes (see Edelman & Gally, 2001). Degeneracy is strongly related to the adaptability and evolvability of a system, and therefore is thought to be favored by natural selection, because it enhances the capacity of a system to carry information, to be robust to damage, and to survive under different conditions (Tononi, Sporns, & Edelman, 1999; Whitacre and Bender, 2010; Whitacre, 2010). Different neural ensembles that are functionally redundant (i.e., produce the same function) in one situation can be functionally distinct (i.e., perform different functions) in different situations. A brain that constructs the same instance of emotion via degenerate neural assemblies would therefore be much more advantageous, from an evolutionary standpoint, than a brain with dedicated neural structures for emotion (for discussion, see Barrett, 2017a). Accordingly, the hypothesis of degeneracy is an important element in the theory of constructed emotion, although it is rarely studied in emotion research (but see these papers for evidence of degeneracy in fear (Becker et al., 2012; Herry and Johansen, 2014; Tovote et al., 2015).

One physical signal, many emotional meanings. The theory of constructed emotion not only hypothesizes that variable physical signals can be categorized to have the same emotional meaning, but a single physical signal or pattern of signals can have different psychological meanings in different situations, in the same way that any object or event can be conceptually categorized in a flexible, situated manner (e.g., a bright yellow dandelion with green leaves might be considered food to eat, a weed to pluck, or a flower to put in a vase, depending on the context). (This follows from Hypothesis 1). When the same physical signals are associated with different mental features, they can take on different emotional meanings. There is evidence that the same facial movements have a variety of psychological meanings (not all of which are emotional; for evidence and discussion, see these papers and references therein: Barrett, in press; Barrett et al., 2019; Gendron et al., 2020; Gendron et al., 2018; the unsupervised machine learning analyses in LeMau et al., 2020). The same physiological motifs have a variety of psychological meanings, even within a single person (e.g., Hoemann et al. 2020). The same neural activity (Lindquist et al., 2012) and even stimulation of exactly the same neurons produce different emotional meanings (e.g., Guillory and Bujarski, 2014; Halgren et al., 1978; Reynolds & Berridge, 2008). (More generally, a single neuron or assembly of neurons can carry different information, sometimes depending on the context; e.g., Kaplan and Zimmer, 2020; Keck et al., 2013; Levinthal and Strick, 2012; Liang et al., 2013; Merabet et al., 2004; Rigotti et al., 2013; Stokes et al., 2013; for a broader discussion, see Anderson, 2014).

It is necessary to discover the variation, not stipulate it, because the variation need not be the same across individuals. For example, across all instances of ad hoc anger construction for a given individual whose brain is equipped to construct instances of anger (i.e., across the entire population of anger instances for that person), there may be some number (N) of distributions with graded similarity in their features, like a vocabulary of angers, that the person's brain is capable of constructing. And, in principle, the vocabulary of ad hoc anger categories (with graded distributions of features) can vary across people, particularly if those people come from different backgrounds with different opportunities for cultural inheritance. So, the epistemological strategy that is required by the theory of constructed emotion involves methods that, in principle, allow observations of such variation if it is present, as well as the discovery of structure in that variation, if it is present. Attempts to understand the causes of emotion, or any psychological phenomenon, will be hampered if sampling of participants, stimuli, and measurements limits this variation, as can be observed in recent machine learning studies of emotion (reviewed in Barrett, in press).

Population Thinking

The hypothesis, then, is that an emotion category has no static, situation-independent, perceiver-independent prototype. The *summary* of any situated category (i.e., any sample of possible feature patterns) is analogous to a prototype that best suits the functional goal of the categorizer in that specific situation (Barsalou and Hale, 1993; Voorspoels et al., 2011). For a given perceiver, a given emotion category therefore has as many prototypes as there are different functional contexts or situations for that perceiver. Fear of starving in the woods, as a situated conceptual category, may have a different prototype for a given perceiver than fear on a rollercoaster, fear of being stung by a bee, fear of being rejected by a lover, or fear of accidentally harming a friend. The implication is that fear — across all instances, in all situations, in all people whose brains are equipped to construct anger — is a *population of events* whose physical features will be *highly* variable, and whose functional features will also be variable, but perhaps less so. At this point, you might ask, "Amidst all this variation, what makes instances of anger what they are — fear — and not some other kind of emotion?" If so, you are asking a typological question that is not meaningful from a constructionist perspective. Across the entire population of fear instances for all creatures whose brains are equipped to make instances of fear, the features of equivalence that create the category will be individual- and situation-dependent, resulting in patterns of features that are highly variable and situated. To the extent that situations differ across cultures, emotion categories will also differ (Mesquita, 2022).

Fortunately, Charles Darwin (Darwin, 1859) provided a conceptual tool for thinking about this magnitude of structured variation. It's called population thinking, named by the evolutionary biologist Ernst Mayr (Mayr, 2004). Population thinking, as articulated in *On the Origin of Species*, refers to the idea that a biological category, such as a species, is a conceptual category of individuals with variable physical features, and whose fitness is inherently relative to the conditions of the immediate environment. William James adapted Darwin's observation to the nature of emotion: "The varieties of emotion are innumerable… The trouble with the emotions in psychology is that they are regarded too much as … eternal and sacred psychic entities, like the old immutable species in natural history … all that can be done is with them is reverently to catalogue their separate characters, points, and effects" ("old immutable species" refers to the pre-Darwinian definition of a species). And James continued, "But if we regard them … as 'species' are now regarded as products of heredity and variation, the mere distinguishing and cataloguing becomes of subsidiary importance." (James, 1998: 449). Since then, population thinking has been periodically revisited in psychological science a number of times (e.g., Estes, 1956; Gallistel, 2013, 2012). The constructionist hypothesis — that any biological category, and correspondingly, any psychological category, including any emotion category, is a population of situation-dependent instances with variable features — is similarly inspired by this Darwinian idea (as discussed in Barrett, 2013; Barrett, 2017a,b; Clark-Polner et al., 2017; Siegel et al., 2018).

In population thinking, variation among a category's instances is assumed to be real in nature, structured, and meaningfully related to the situations in which those instances emerge. Any abstract summary of a category, such as its mean or a prototype, is a fiction. (By analogy, the average US household size in 2020 was 2.53 people, but no real family contains 2.53 individuals.) In machine learning analyses that search for a single pattern to summarize multiple participants, any such pattern is an abstraction that need not exist in any participant's data; i.e., in any given brain imaging study, the so-called biomarkers for emotions are abstractions (à la population thinking), not actual brain states (à la typological thinking; for a mathematical simulation, see Clark-Polner et al., 2017). The same can be said for machine learning analyses of any set of signals.

Magnitude of Variation

A typological perspective allows for some amount of variation in the features of an emotion category and some degree of similarity in features across categories. When it comes to the issue of variation, a typological perspective is distinguished from a constructionist perspective by the magnitude of variation that is predicted and the way in which that variation is explained.

In causal appraisal models, for example, variability in instances of the same emotion category is thought to be limited only by the variety of possible meaning combinations that appraisals, as cognitive mechanisms, can produce. In practice, however, most published research has focused on trying to identify the single pattern (of cognitive evaluations, action tendencies, relational themes, etc.) that identifies certain emotion types, like anger, sadness, fear, and so on.

This focus on emotion types can be seen historically. For example, in 1894, Irons wrote "There is no such thing as a perfectly definite set of organic changes constituting the expression of any particular emotion, and the 'perpetual variation' of the bodily elements, while the character of the emotion remains unchanged, renders discrimination of the spiritual element not only possible but unavoidable" (Irons, 1894: 82). This focus on emotion types is echoed by Arnold (1960), who wrote that appraisals, as cognitive mechanisms, triggered instances that she referred to as "basic" emotion categories. She wrote, "For each emotion, there is a distinct pattern that remains more or less constant and is recognized as characteristic for that emotion", and "[w]hether we are afraid of a bear, a snake, or a thunderstorm, our bodily sensations during these experiences are very much alike. . . . there will always be a core that is similar from person to person and even from man to animal" (Arnold, 1960: 179). (It must be noted, however, that more recent investigations are, in fact, observing and modeling variation; e.g., Kuppens, 2010; Kuppens et al., 2008, 2007; Nezlek et al., 2008).

Variation is also acknowledged in basic emotion views. Types of emotion are hypothesized to be expressed by a family of related physical signals (e.g., Ekman, 1992). This means that some natural variation is to be expected. In other words, an expression of anger can look somewhat different on different occasions but remains an expression of the underlying type (for stipulated variation, see refs). It is hypothesized that each type of emotion, as a category, has a prototype, i.e., an instance with a pattern of features that best describes all the category's instances (e.g., Cowen and Keltner, 2021). A category's prototype might be its most frequently observed instance (i.e., a typical instance) or its most representative instance. Individual instances of the category might vary in their features across situations, people, and cultures, creating a distribution (or family) of physical signals, but the prototype, as a conceptual representation of the entire distribution, must share a family resemblance with them. The prototype's features must be similar enough to the other category instances in the distribution, and different enough from the prototypes of other categories, to diagnose a new instance reliably and specifically as belonging to its specific emotion category (for specific quotations, see Ekman, 1992: 197; Ekman and Cordaro, 2011: 364; Levenson, 2011: 379; Scarantino and Griffiths, 2011: 448-449).

Indeed, in a typological view of emotion, an emotion prototype is considered to be a reliable suite of coordinated features (e.g., in peripheral physiology, motivation, and behavior) that serves as an evolved adaptation to a specific fitness-relevant challenge (Shariff and Tracy, 2011). Prototype categories have fuzzy boundaries, meaning their instances occasionally share some features with instances of other categories, and this is where context comes in. A wrinkled nose and scrunched up eyes, for example, are assumed by themselves to be an evolutionarily-preserved, prototypical expression of disgust (Shariff and Tracy, 2011), but this configuration might express anger when it occurs attached to a body with balled fists (see Aviezer et al., 2008). This sort of contextual shaping of a physical feature's emotional meaning is assumed to be the exception rather than the rule (Cowen and Keltner, 2020: 361), or are caused by stochasticity, differences in induction methods, or processes that are separate from but act on instances of emotion, such as emotion regulation and cultural norms for expressing emotion (such as, for example, display rules or cultural dialects; e.g., Ekman and Cordaro, 2011; Elfenbein, 2013; Levenson, 2011; Matsumoto, 1990; Roseman, 2011; Tracy and Randles, 2011).

Through the lens of the theory of constructed emotion, variation is an intrinsic and adaptive aspect of emotional function and derives from the basic functioning of the brain. And any summary of a category, such as a prototype, is a fiction — what is real is the variation (this is a basic principle of population thinking; Barrett, 2017, 2020; Mayr, 2004). We wonder, given magnitude of featural variation that has been observed within emotion categories and featural similarity that has been observed across emotion categories (and even in non-emotion categories), what sort of observations are capable of disconfirming a typological perspective? How far can a typological view be stretched before it breaks?

When viewed through the lens of population thinking, the prototypes for each emotion category proposed by typological approaches — the coordinated patterns of physiology, expressive movements, neural assemblies, and so on, that are supposedly stable across situations, people, and cultures — might be considered stereotypes (Barrett, 2017b; Barrett et al., 2019): oversimplified beliefs about emotion that are taken to be more applicable and diagnostic than they actually are. Some cultures may have similar emotion stereotypes, but this says nothing about the actual degree of structured variation among instances of emotion in the individual people of a given culture or how similar that variation is to any other culture.

Summary

Hypothesis 2 of the theory of constructed emotion can be restated thus: An emotion category label, such as "fear," when referring to all instances, in all situations, in all creatures whose brains are equipped to construct anger, is a *population of context-specific events* whose physical features will be *highly* variable, and whose functional features will also be variable, but perhaps less so. Each instance of the category is, itself, assembled in a brain that continually constructs situated conceptual categories to coordinate and guide action and construct the features of experience in a metabolically efficient manner. This variation arises because physical signals such as heart rate variability, skin conductance, serotonin release and uptake, smiles, frowns, scowls, vocalizations, etc. have no inherent, biologically prepared emotional meaning.

Physical features are *made* meaningful as an instance of emotion as a brain predicts that, in a given situation, *these features are functionally similar to past instances of that emotion category*.

Hypothesis 3: Cultural Inheritance

Hypotheses 1 and 2 of the theory of constructed emotion assume that a brain is equipped with past episodes of emotion, which can be used to assemble the situated, conceptual categories of emotion that are needed to achieve the predicted functional outcomes. Where does this emotion knowledge come from, if not inherited by genes? The theory of constructed emotion hypothesizes that emotion knowledge is acquired via the processes of cultural inheritance.

Humans are powerful statistical learners who can absorb complex, dynamically changing patterns of information in a short time. For example, young children quickly learn the emotional meaning of facial movements that they have probably never encountered before and can learn new categorizations for facial movements, based on associations with contextual features in as little as 12 minutes of experience (Woodard et al., 2021b; also see Plate et al., 2022, 2019; Woodard et al., 2021a). This learning is ubiquitous, particularly when words are available to help. Words are powerful invitations to learn categories (Waxman and Gelman, 2010), even for very young infants (Vouloumanos and Waxman, 2014), and are particularly useful for learning abstract categories and concepts (for discussion and references, see Barrett, 2017a; Hoemann, Wu, et al., 2020). Such "supervised category learning" may, in fact, be an important source of emotional development (Hoemann et al., 2020b, 2019b) and support the transmission of cultural knowledge across generations, called cultural inheritance, more generally (Gelman and Roberts, 2017; Gendron et al., 2020b).

They theory of constructed emotion hypothesizes that culture has an evolutionary role in transmitting knowledge about emotion concepts from one generation to the next, as tools for regulating the body (Barrett, 2017a,b) and for regulating each other (i.e., if we make ourselves predictable to others, they become more predictable to us, which reduces the metabolic burden of social life for everyone; (Theriault et al., 2021b). The hypothesis is not that humans evolved particular signals, such as facial movements, physiological changes, or even patterns of neural firing with particular genetically encoded emotional meanings, which is a standard hypothesis in evolutionary psychology. Instead, there is growing evidence that a human is born with their brain under construction (e.g., Gao et al., 2017; Gilmore et al., 2018; Grayson and Fair, 2017; Zuo et al., 2017). Signals from the physical and social world are necessary inputs for the brain to develop the capacity to model its body in the world and to compute abstract mental features. This creates an opportunity for cultural inheritance (e.g., Boyd et al., 2011; Richerson and Boyd, 2008), in addition to genes, to transfer information across generations. During development and the processes that we call "socialization," via the words (Gelman and Roberts, 2017) and actions of others (e.g., Atzil et al., 2018; Gendron et al., 2020b; Mesquita, 2022), it is hypothesized that culture creates recurrent situations that allow a brain to learn specific, situated meanings of particular signals in the natural and cultural ecology of a person's environment. As human brains develop, they grow micro-wiring that enables them to construct mental features in culturally relevant ways, including their attentional capacities for deciding which signals are relevant and which are noise to be safely ignored. An obvious example is the ways in which a young brain tunes and prunes with experience to hear certain speech sounds while losing the capacity to hear others.

In this way, a human brain develops the wiring to model its body and the world it inhabits. It becomes encultured with the knowledge to create meanings that are relevant to a particular set of cultural practices and values. As children develop into adults and interact with their world, they create some of the signals in the environment (by their words and actions) that will wire the brains of the next generation. We hypothesize that emotion acculturation (Batja, 2022), when people move from one cultural context to another, proceeds via the same processes (for discussion, see Barrett, 2017a, b). These hypotheses are consistent with our evolved roles as social animals and our ability to collectively create social reality (Barrett, 2012, 2017a, b, 2020).

Evolution has produced is a human brain architecture with the capacity for flexible, situated meaning-making that can be synchronized across minds within a culture and across generations. We hypothesize that such synchrony of relational meanings across brains is the basis for emotional communication, and communication of any other sort (e.g., Gendron and Barrett, 2018; Nguyen et al., 2021; Nozawa et al., 2019). It also allows people to influence one another physically with words and body movements such as the raise of an eyebrow or the curl of a lip, for better or for worse.

Misunderstandings and Mischaracterizations of the Constructionist Perspective

When people attempt to understanding the theory of constructed emotions through the lens of typological assumptions (for discussion, see Barrett, 2015, in press), they commonly misunderstand it. Here, we discuss several popular mistakes that can be found in the published literature, and even in this volume.

The Theory of Constructed Emotion is Not a "Cognitive" View of Emotions

The theory of constructed emotion is not a "cognitive" view of emotions (as mistakenly claimed by some, e.g., Leys, 2017). Traditional western folk psychological categories such as "cognition," "emotion," "perception," "motivation," "action" and so on constitute a particular, culturally-specific theory of mind (Danziger, 1997; Mesquita, 2022) that neither describes nor explains the behavior and experience of many humans around the world. These categories are not respected by the anatomy or functioning of the brain (e.g., Barrett, 2009; Barrett, 2017a,b; Buzsáki, 2019; Kleckner et al., 2017), nor by the evolution and development of the nervous system (e.g., Cesario et al., 2020; Cisek, 2019b). Therefore, it makes no sense to refer to “cognitive” processes and “emotional” processes as if they are separate and interact with one another to produce behavior.

The Theory of Constructed Emotion Integrates Individual- and Social-Focused Understanding of Emotions

The theory of constructed emotion has been mischaracterized as a “radically individualist” perspective in which instances of emotion arise from processes that are solely internal to an individual person (Eustace, 2019, p. 52). The theory of constructed emotion, by contrast, hypothesizes that meaning making occurs in an extended context of interdependent brains. Conceptually, it can handle both western conceptions of emotions as internal feelings or states and conceptions from other parts of the world where instances of emotions are situated transactions between individuals (e.g., Hoemann et al., under review and references therein). It is, in effect, a hypothesis about the neurobiology and physiology of social construction.

Valence and Arousal Are Not Sufficient Features of Emotion

Many works on the nature of emotion mischaracterize the distinction between typological views and constructionist views, associating the former with discrete emotion categories (with firm or fuzzy boundaries) and the latter with affective dimensions. They mischaracterize construction as a “dimensional approach,” whose dimensions are typically said to be valence and arousal, and then they criticize construction regarding limitations of dimensional approaches (e.g., Coppin and Sander, 2021; Fontaine et al., 2007). The correct, key distinction between typological and construction approaches is as follows: both approaches acknowledge the existence of emotion categories but put forth very different hypotheses on the nature and origin of those categories.

This mistaken characterization of constructionist views as “dimensional” has also morphed into the mistaken claim (or gross mischaracterization) that constructionist views reduce instances of emotion to combinations of the affective features of valence and arousal (i.e., that instances of emotion can be sufficiently explained by valence and arousal; e.g., Cowen & Keltner, 2020). Constructionist approaches like the theory of constructed emotion and others (e.g., Russell, 2003) hypothesize that valence and arousal are *necessary* features of emotional instances, but as far as we are aware, no modern constructionist account of emotion suggests that affective features are sufficient for describing or explaining emotional instances. The affective circumplex is not and never has been presented as an explanatory theory of emotion. It is a descriptive map that represents two properties or features of consciousness, including the moments of consciousness that constructed as instances of emotion. As features of experience, valence and arousal are descriptive properties, not causal mechanisms (i.e., they are not causal evaluations as proposed by causal appraisal approaches).

Neither are valence and arousal unique to emotion — they are fundamental features of all thoughts, beliefs, memories, perceptions, and so on (e.g., Lebrecht et al., 2012; Osgood et al., 1957; Satpute et al., 2015). Simply put, they are descriptive features of consciousness (for a discussion, see (Barrett and Bliss-Moreau, 2009; Wundt, 1897/1998). One well-known constructionist hypothesis by Russell (2003) and a well-known descriptive appraisal view by Clore & Ortony (Clore and Ortony, 2013, 2008) are agnostic as to how affective feelings arise. The theory of constructed emotion hypotheses that valence and arousal are low dimensional (i.e., multi-modal, compressed) features that emerge from the brain’s predictive regulation of the body (allostasis) and its model of the body's state (interoception) that arises from that regulation. It is notable that, as hypothesized by the theory of constructed emotion, affective features vary across instances of the same emotion category (e.g., Wilson-Mendenhall et al., 2015, 2013). Given that instances of the same emotion category vary in their affective features, the placement of emotion words on the affective circumplex reflects, at best, the prototypic affective feelings during the instances within the associated category (Russell, 2003), and at worst, a stereotype.

Prototypes are Orthogonal to Construction

A prototype view of emotion assumes that there is one concept (the prototype) for a category, and that concept is the single most representative and/or typical instance of the category. Since the 1980s, prototype views of emotion have been repeatedly offered by those who endorse a typological view of emotion (e.g., Roseman, 2011; Shaver et al., 1987) *as well as* those who are strong critics of the typological perspective and take a constructionist approach (e.g., Fehr and Russell, 1984; Russell, 2003, 1991b). Recently, studies that were designed and modeled to find evidence of prototypes, and that, indeed, reported observing those prototypes, have interpreted these findings as evidence that certain patterns of physical signals have inherent, biologically prepared (i.e., innate) emotional meanings. But concluding that emotion categories are structured as prototypes implies nothing whatsoever about whether or not emotional meanings are innate or learned during development; nor do they settle the question of whether participants are recognizing emotional meanings vs. constructing them the spot.

A Constructionist Perspective Can Be an Evolutionary Perspective

Typological approaches are described as "evolutionary" approaches to emotion, with their proposal that the prototype of each emotion category arises from a "pan-cultural affect program" (Scarantino, 2018) that evolved as an adaptation to recurrent fitness challenge (Shariff and Tracy, 2011), and that is modified in context specific ways by experience-based learning. But they are merely *one flavor* of evolutionary approach, one that assumes that transmission of emotion types across generations is primarily carried by genes, which contain the blueprints for specific, inborn circuits that are thought to be adaptations. This approach has much in common with what is called the "modern synthesis," which is popular in evolutionary psychology. In this view, context and learning can influence what nature selects, and maybe how it selects, but they do not transfer the information that *creates* phenotypic characteristics.

The theory of constructed emotion also considers the capacity for emotions as part of evolutionary inheritance, but DNA alone is not the conduit of information transfer from one generation to the next, consistent with a perspective called the "extended evolutionary approach" (e.g., Laland et al., 2015). In this view, humans have the kind of genes that make the environment a necessary and equal cause of information transfer that wires young human brains and maintains or alters that wiring throughout the course of life. Cultural inheritance (see Hypothesis 3), epigenetics (environmental exposures and experiences turn genes on and off), and gene-culture co-evolution (just what it sounds like) are a few of the concepts with empirical findings that are useful to guide constructionist inquiries about emotion. The extended evolutionary synthesis views cultural inheritance (for example) as an efficient, frugal partner to genetic inheritance so that adaptations to recurring fitness challenges needn't be encoded in our genes. Culture wires our brains, which directs how we act towards one another, which in turn wires the brains of the next generation. This is how humans, by virtue of the cultures we create, nudge the evolutionary trajectory of our species.

In our view, there is no single, universal human nature with a single set of universal emotion categories. The emotion categories that a human brain is wired to construct, and the experiences of the world and the emotional meanings of actions and sensory signals that result, are not necessarily universal (as evidenced from numerous ethnographies in cultural and psychological anthropology, as well as the various compendia of emotion concepts that appear online; also see (Smith, 2015). Instead, the hypothesized universals are the neural processes that create categories, and cultural shaping of category learning. In short, we have the kind of nature that requires nurture (Barrett, 2020).

If you think about it for a moment, the idea of "recurrent fitness challenges" as an ecological context for shaping the evolution of prototypes implies that human emotions must exist as conceptual categories, and that typological theorists themselves are using such categories. The need to communicate a threat, the need to appease, the need to communicate dominance, and other supposed "recurrent fitness challenges" are abstract, functional features, constructed in any human brain as compressed, multimodal summaries. Each summary must be mapped to low level sensory and motor signals to allow for perception and action. The sensory and motor specifics likely vary tremendously, given the breadth of human niches around the world, the variety of social arrangements that humans organize themselves into, the fluctuations in circadian rhythms throughout each day, and so on.

Considerations and Questions

We've skipped a number of relevant issues in this chapter, to keep it from growing into an entire book. For example, the theory of constructed emotion is consistent with (and contributes to the evidence for) grounded cognition and embodied concepts. We have not delved into the evolution of the vertebrate nervous system, the neuroscience of continuous category construction and prediction (i.e., the neurobiology of social and psychological construction), our friendly amendments to LeDoux's "survival circuit" perspective, nor the metabolic costs and benefits of having a brain that uses concepts and categories to guide motor action. There are also numerous historical and philosophical issues that we have not touched on, as well as important contributions from linguistics, comparative neuroscience, anthropology, and other related fields that we have overlooked. Nonetheless, we hope it is clear that the theory of constructed emotion, as a multidisciplinary constructionist approach, opens up a new conceptual space that changes the questions we ask about the nature of emotion, and ultimately, about the nature of human minds. Accordingly, here are a few examples of such questions.

Instances of Emotion Are First-Person Phenomena

A constructionist account studies instances of emotion as first-person phenomena, not third-person phenomena that happen independent of person and spatio-temporal context. Instances of emotion are always in relation to a particular categorizer. A constructionist approach asks, for example, questions about how a brain chooses and constructs features of equivalence; what are the mechanisms by which category construction works; how categorization proceeds; how bodily regulation, actions and experiences emerge from this construction process; and what conditions produce similar prototypes across situations and people to allow for communication and category learning. But we never ask, “What is anger?” as if anger were a third-person phenomenon that can be studied by simply measuring a coordinated suite of changes in expression, autonomic physiology, and subjective feelings. Ditto for the question of whether anger can be recognized in a physical feature, such as a facial expression, or even in a small ensemble of physical features, such as facial movements, changes in heart rate or skin conductance, and body postures. Instances of emotion in oneself, or as perceived in others, exist only from the perspective of a brain that can categorize and make meaning. Emotional meaning does not reside in physical features themselves. The mental features that serve as the features of equivalence, and that give physical features their emotional meaning, do not exist in world or in the body. They exist only in the brain that created the features. As a consequence, when studying instances of emotion, we must measure more than physical signals from the face, body, voice, and so on. We must also measure the brain signals that give those physical signals their psychologically meaning.

Who is Constructing What?

It is common for human scientists to observe a fly freezing, a rat running, and a human gasping with a wide-eyed stare, and conclude (categorize) that all three animals are in a state of fear, functionally defined by the goal to protect from threat. The three events have vast physical differences, but a human brain can construct such a category of fear, because it can compute an abstract feature of equivalence that *creates* the similarity (in this example, the goal). Now, consider the brains of flies and rats — are they architecturally equipped to compute such abstract features? If not, then in *whose brain* does this state reside? (Hint: it's not the fly's or the rat's.) This is our point when we describe instances of emotion and emotion perception as first-person, perceiver-dependent events, not third-person, perceiver-independent phenomena (Barrett, 2012, in press). A fly's fearful state is real for human scientists, but perhaps not for the fly whose brain may not be capable of computing abstract features like "a goal to protect against threat" when making sensory signals meaningful as actions in its niche. Even perceiving an animal as "running" is, in fact, an abstraction from briefer, more basic (and perhaps innate) muscle motifs that can be flexibly assembled in a specific situation (in relation to the signals therein. Such notions call into question the "perceiver-independence" of functional views of emotion and the mind that confuse scientific consensus with objectivity.

Empirical Strategies

Establishing the empirical status of the constructionist perspective is a Herculean task because, as we explained in the history and background sections, a constructionist perspective draws from multiple research domains that stretch well beyond the traditional boundaries that demarcate the science of emotion, and as a consequence, a comprehensive review of supporting evidence goes beyond the scope of this chapter. Furthermore, most scientific studies that have been (and continue to be) published in the science of emotion use empirical strategies that are guided by typological assumptions. In principle, such studies cannot provide a rigorous test of constructionist hypotheses because their sampling of stimuli, scope of measurement, and modeling assumptions are implicitly designed to describe a typology of emotion categories whose instances are similar across instances, situations, people, and cultures (for an explanation, see Barrett, 2015, in press).

Hypotheses grounded in radically different assumptions, like those of the constructionist perspective, require different empirical strategies, and this presents a problem because the hypotheses are counterintuitive (e.g., relational meaning) or often misunderstood (e.g., variation). Science is a human activity that operates in a social context, and therefore any decision regarding which methods count as acceptable tools of scientific inquiry depends on shared goals and agreements. Without those agreements, novel empirical strategies are not accepted. As a consequence, it becomes necessary to build an empirical foundation solely to justify the need for those empirical strategies, and a major project for constructionist thinkers over the past several decades has been to empirically demonstrate the need for specific alternative methods to properly test constructionist hypotheses. Nonetheless, the existing body of evidence, encompassing both those findings that run counter to the typological view and those that support it (when considered in their full context), is consistent with, and in most cases predicted by, the constructionist perspective.

Constructionism as Relational Realism

In philosophy, there has been a longstanding debate about the nature of reality: is there a mind-independent material reality (called realism) with natural kind categories to be discovered or does reality and its categories exist only in a person's head (called idealism). Unless you are a dualist who believes in spiritual or other substances that are not of the material world, the issue at hand is not whether categories are real, but rather what is meant by the word "real" and just what makes a category "real." For scientists, a useful way to rephrase the question is: do the categories we study exist in reality that is independently of human brains and the concepts they construct or do the categories we study exist only in relation to human brains and concepts – do human concepts make the categories real? This latter mindset is not idealism but the philosophical mindset we have been exploring here: constructionism (or constructivism). Constructionism means a lot of different things in philosophy, but the flavor that we've consider here is a fully relational view of reality in which features of equivalence and the categories they create are constructed in (and exist in relation to) the brains of the creatures using them (see Barrett, 2022). Relational realism is distinct from traditional scientific realism (which assumes that features of equivalence and categories exist are mind-independent), but it is not an "anything goes" form of relativism that is often associated with idealism.

In this chapter, we've unpacked the debate between traditional realism (represented by discrete emotion and basic emotion approaches) and relational realism (represented by the theory of constructed emotion) into questions about the nature of emotion categories and concepts. One set of questions has to do with *the degree of similarity (or variation)* among instances belonging to the same category as well as the degree of similarity (or distinctiveness) in instances of different categories. A second set of questions address the *stability of similarities and differences,* whether the categories and their features of equivalence are stable across time, place, individuals and species. A third set of questions deals with *the nature of the features that ground the category* (i.e., the features make the instances equivalent to one another): Do the features of equivalence and therefore the equivalence classes (i.e., categories) exist independently of human perceivers or do they depend on human perceivers? Are sensory and motor details the key features of equivalence within a category or do the similarities transcend those details (i.e., are the features of equivalence abstract and functional)?

Here's a way to summarize the theory of constructed emotion as relational realism: an instance of emotion (like an instance of any psychological category) is a specific spatiotemporal pattern of features that can be characterized as a position within a high-dimensional space of features or properties that a brain can compute (given its architecture as well as the structure of the animal's body, its sensory surfaces, and its broader ecology). Within a human brain, as we discussed above, the relevant feature space ranges from low-level sensory features (closer to the features transduced in the body's sensory surfaces) and lower level motor features (found in the brainstem right before those signals project to the modules in spinal cord) to compressed, multimodal summaries computed at the midline, front of the brain (e.g., valence, arousal, reward, effort, etc.); these are abstract features that can decompress to a variety of different sensorimotor patterns). Signals travel and are compressed or decompressed along various architectural gradients from sensory surfaces to the brain, including up the neuraxis that extends from brainstem to forebrain and within the cerebral cortex, the hippocampus and cerebellum (for discussion and references therein see Katsumi et al., 2022, 2023; Shaffer et al., 2023). The abstract, compressed multimodal features do not exist in the world (e.g., valence, arousal, threat, reward, novelty); they are constructed in the brain. The human brain is capable of degrees of abstraction so far not observed in any other species (although other animals can compute features we cannot). The theory of constructed emotion hypothesizes that low-level sensory and motor features have no inherent biological or psychological meaning. They are made meaningful in relation to abstract features via the processes we've hypothesized in this chapter (variously described as "predictive processing" and "category construction/categorization." Their meaning derives from their relation to other signals, particularly those that exist *only* in a human brain — prediction signals (a.k.a. ad hoc categories), which are continually constructed in a situation-specific manner. Emotion categories and their instances are real, but their reality is relational (Barrett, 2012). They don't exist in the world, independently of human perceivers. They don't exist only in the heads of human perceivers. They exist in a reality that is constituted by the relations between signals in human brains, signals arising from human bodies, and signals arising from the world (which importantly includes other human brains in bodies).

Conclusions

The theory of constructed emotion is both old and new. Its threads extend back thousands of years to Ancient Greece, when the philosopher Heraclitus famously wrote, "No man ever steps in the same river twice," because only a mind perceives an ever-changing river as a distinct body of water. The theory is also a thoroughly novel approach that owes its potential scientific utility to ideas and empirical findings from many scholars in different fields that span the sciences, social sciences, humanities, and engineering. It challenges many prevailing ideas about emotion by way of counterintuitive notions like predictive processing and ad hoc category construction, and novel tools are required to evaluate the theory, some of which must still be invented. New ideas, especially those with the potential to turn a field on its head, often meet tremendous resistance. This is because there is a lot at stake. Kuhn made this point in his famous (and contentious) book on scientific revolutions (Kuhn, 1962). So did the evolutionary biologist John Haldane, who characterized the acceptance of new scientific ideas as a process of four stages: "1. This is worthless nonsense, 2. This is an interesting, but perverse point of view, 3. This is true, but quite unimportant, 4. I've always said so" (Haldane, 1963).

The science of emotion is more than a set of inquiries into the nature of emotion. It's also a set of hypotheses about human nature, our relationship to the world around us, and even the nature of reality. In the theory of constructed emotion, emotional meaning arises from a complex web of interdependent signals in the brain, body, and world. The constructionist perspective is more than a conceptual system for understanding how phenomena are caused. It is also a conceptual system for what phenomena are — an ontology of what exists.

References

Anderson, M.L., 2014. After phrenology: Neural reuse and the interactive brain. MIT Press.

Anderson, M.L., Finlay, B.L., 2014. Allocating structure to function: the strong links between neuroplasticity and natural selection. Frontiers in human neuroscience 7, 918. https://doi.org/10.3389/fnhum.2013.00918

Atzil, S., Gao, W., Fradkin, I., Barrett, L.F., 2018. Growing a social brain. Nat Hum Behav 2, 624–636. https://doi.org/10.1038/s41562-018-0384-6

Averill, J.R., 1980. A Constructivist View of Emotion, in: Plutchik, R., Kellerman, H. (Eds.), Theories of Emotion. Academic Press, pp. 305–339. https://doi.org/10.1016/B978-0-12-558701-3.50018-1

Aviezer, H., Hassin, R.R., Ryan, J., Grady, C., Susskind, J., Anderson, A., Moscovitch, M., Bentin, S., 2008. Angry, disgusted, or afraid? Studies on the malleability of emotion perception. Psychol Sci 19, 724–732.

Azari, B., Westlin, C., Satpute, A.B., Hutchinson, J.B., Kragel, P.A., Hoemann, K., Khan, Z., Wormwood, J.B., Quigley, K.S., Erdogmus, D., Dy, J., Brooks, D.H., Barrett, L.F., 2020. Comparing supervised and unsupervised approaches to emotion categorization in the human brain, body, and subjective experience. Sci Rep 10, 20284. https://doi.org/10.1038/s41598-020-77117-8

Barrett, L.F., 2020. Seven and a Half Lessons About the Brain. Houghton Mifflin Harcourt, Boston, MA.

Barrett, L. F., 2017a. How emotions are made: The secret life the brain. Houghton-Mifflin-Harcourt, a.

Barrett, L.F, 2017b. The theory of constructed emotion: An active inference account of interoception and categorization. Social Cognitive and Affective Neuroscience 12, 1–23. https://doi.org/10.1093/scan/nsw154

Barrett, L.F., 2015. Ten common misconceptions about the psychological construction of emotion, in: Barrett, L.F., Russell, J.A. (Eds.), The Psychological Construction of Emotion. Guilford, New York NY, pp. 45–79.

Barrett, L.F., 2013. Psychological construction: The Darwinian approach to the science of emotion. Emotion review 5, 379–389.

Barrett, L.F., 2012. Emotions are real. Emotion 12, 413–429. https://doi.org/10.1037/a0027555

Barrett, L.F., 2009. The Future of Psychology: Connecting Mind to Brain. Perspect Psychol Sci 4, 326–339. https://doi.org/10.1111/j.1745-6924.2009.01134.x

Barrett, L.F., 2006. Solving the Emotion Paradox: Categorization and the Experience of Emotion. Pers Soc Psychol Rev 10, 20–46. https://doi.org/10.1207/s15327957pspr1001_2

Barrett, L.F., in press. Context reconsidered: Complexity, variation and relational meaning. American Psychologist.

Barrett, L.F., Bliss-Moreau, E., 2009. She’s emotional. He’s having a bad day: Attributional explanations for emotion stereotypes. Emotion 9, 649–658. https://doi.org/10.1037/a0016821

Barrett, L.F., Finlay, B.L., 2018. Concepts, goals and the control of survival-related behaviors. Current Opinion in Behavioral Sciences 24, 172–179. https://doi.org/10.1016/j.cobeha.2018.10.001

Barrett, L. F., Lindquist, K., Gendron, M., 2007. Language as a context for emotion perception. Trends in Cognitive Sciences 11, 327–332.

Barrett, Lisa Feldman, Lindquist, K.A., Bliss-Moreau, E., Duncan, S., Gendron, M., Mize, J., Brennan, L., 2007. Of Mice and Men: Natural Kinds of Emotions in the Mammalian Brain? A Response to Panksepp and Izard. Perspect Psychol Sci 2, 297–312. https://doi.org/10.1111/j.1745-6916.2007.00046.x

Barrett, L.F., Mesquita, B., Ochsner, K.N., Gross, J.J., 2007. The Experience of Emotion. Annu. Rev. Psychol. 58, 373–403. https://doi.org/10.1146/annurev.psych.58.110405.085709

Barrett, L.F., Russell, J.A., 2015. The psychological construction of emotion. Guilford Publications, New York.

Barrett, L.F., Satpute, A.B., 2013. Large-scale brain networks in affective and social neuroscience: towards an integrative functional architecture of the brain. Current opinion in neurobiology 23, 361–372.

Barrett, L.F., Simmons, W.K., 2015. Interoceptive predictions in the brain. Nat Rev Neurosci 16, 419–429. https://doi.org/10.1038/nrn3950

Barsalou, L.W., 1992. Cognitive psychology: An overview for cognitive scientists. Erlbaum, Mawah, NJ.

Barsalou, L.W., 1987. The Instability of Graded Structure: Implications for the for the nature of concepts, in: Neisser, U. (Ed.), Concepts and Conceptual Development. Cambridge, pp. 101–140.

Barsalou, L.W., 1983. Ad hoc categories. Memory & cognition 11, 211–227.

Barsalou, L.W., Hale, C.R., 1993. Components of conceptual representation: From feature lists to recursive frames, in: Mechelen, I.V., Hampton, J., Michalski, R., Theuns, P. (Eds.), Categories and Concepts: Theoretical Views and Inductive Data Analysis. Academic Press, San Diego, CA, pp. 97–144.

Barsalou, L.W., Kyle Simmons, W., Barbey, A.K., Wilson, C.D., 2003. Grounding conceptual knowledge in modality-specific systems. Trends Cogn Sci 7, 84–91.

Barsalou, L.W., Wilson, C.D., Hasenkamp, W., 2010. One the vices of nominalization and the virtues of contextualizing, in: Barrett, L.F., Mesquita, B., Smith, E. (Eds.), The Mind in Context. Guilford Press, New York, pp. 334–360.

Bateson, G., Mead, M., 1942. Balinese character. New York Academy of Sciences, New York.

Bechtel, W., Bich, L., 2021. Grounding cognition: heterarchical control mechanisms in biology. Philosophical Transactions of the Royal Society B: Biological Sciences 376, 20190751. https://doi.org/10.1098/rstb.2019.0751

Becker, B., Mihov, Y., Scheele, D., Kendrick, K.M., Feinstein, J.S., Matusch, A., Aydin, M., Reich, H., Urbach, H., Oros-Peusquens, A.-M., 2012. Fear processing and social networking in the absence of a functional amygdala. Biological psychiatry 72, 70–77.

Biess, F., Gross, D.M. (Eds.), 2014. Science and Emotions after 1945: A Transatlantic Perspective. University of Chicago Press, Chicago, IL.

Blanchard, D.C., Blanchard, R.J., 1988. Ethoexperimental Approaches to the Biology of Emotion. Annual Review of Psychology 39, 43–68.

Boddice, R., 2019. A history of feelings. Reaktion Books, London.

Boiger, M., Mesquita, B., 2012. Emotion Science Needs to Account for the Social World. Emot Rev 4, 236–237. https://doi.org/10.1177/1754073912439789

Boyd, R., Richerson, P.J., Henrich, J., 2011. The cultural niche: Why social learning is essential for human adaptation. Proceedings of the National Academy of Sciences 108, 10918–10925.

Bruner, J., 1990. Acts of meaning, Acts of meaning. Harvard University Press, Cambridge, MA, US.

Buzsáki, G., 2019. The brain from inside out. Oxford University Press.

Casasanto, D., Lupyan, G., 2015. All Concepts Are Ad Hoc Concepts. Conceptual Mind: New Directions in the Study of Concepts 543–566.

Cesario, J., Johnson, D.J., Eisthen, H.L., 2020. Your Brain Is Not an Onion With a Tiny Reptile Inside: Current Directions in Psychological Science 29, 55–260. https://doi.org/10.1177/0963721420917687

Ceulemans, E., Kuppens, P., Van Mechelen, I., 2012. Capturing the Structure of Distinct Types of Individual Differences in the Situation-specific Experience of Emotions: The Case of Anger. Eur J Personality 26, 484–495. https://doi.org/10.1002/Per.847

Chanes, L., Barrett, L.F., 2016. Redefining the Role of Limbic Areas in Cortical Processing. Trends in Cognitive Sciences 20, 96–106. https://doi.org/10.1016/j.tics.2015.11.005

Cisek, P., 2019a. Resynthesizing behavior through phylogenetic refinement. Atten Percept Psychophys 81, 2265–2287. https://doi.org/10.3758/s13414-019-01760-1

Cisek, P., 2019b. Resynthesizing behavior through phylogenetic refinement. Atten Percept Psychophys 81, 2265–2287. https://doi.org/10.3758/s13414-019-01760-1

Clark, A., 2013. Whatever next? Predictive brains, situated agents, and the future of cognitive science. The Behavioral and brain sciences 36, 181–204. https://doi.org/10.1017/S0140525X12000477

Clark-Polner, E., Johnson, T.D., Barrett, L.F., 2017. Multivoxel Pattern Analysis Does Not Provide Evidence to Support the Existence of Basic Emotions. Cereb. Cortex 27, 1944–1948. https://doi.org/10.1093/cercor/bhw028

Cleland, T.A., Borthakur, A., 2020. A Systematic Framework for Olfactory Bulb Signal Transformations. Front. Comput. Neurosci. 14, 579143. https://doi.org/10.3389/fncom.2020.579143

Clore, G.L., Ortony, A., 2013. Psychological construction in the OCC model of emotion. Emotion Review 5, 335–343.

Clore, G.L., Ortony, A., 2008. Appraisal theories: How cognition shapes affect into emotion, in: Lewis, M., Haviland-Jones, J.M., Barrett, L.F. (Eds.), Handbook of Emotions. Guilford Press, New York, NY, pp. 628–642.

Coppin, G., Sander, D., 2021. Chapter 1 - Theoretical approaches to emotion and its measurement, in: Meiselman, H.L. (Ed.), Emotion Measurement (Second Edition). Woodhead Publishing, pp. 3–37. https://doi.org/10.1016/B978-0-12-821124-3.00001-6

Cowen, A.S., Keltner, D., 2021. Semantic Space Theory: A Computational Approach to Emotion. Trends in Cognitive Sciences 25, 124–136. https://doi.org/10.1016/j.tics.2020.11.004

Craik, K.J.W., 1944. The Nature of Explanation. Philosophy 19, 173–174. https://doi.org/10.1017/S0031819100004733

Cunningham, W.A., Dunfield, K.A., Stillman, P.E., 2013. Emotional states from affective dynamics. Emotion Review 5, 344–355.

Danziger, K., 1997. Naming the Mind: How Psychology Found Its Language. SAGE.

Darwin, C., 1859. On the origin of species., A facsimile of the first edition. ed. Harvard University Press., Cambridge, MA.

Dashiell, J.F., 1928. Are there any native emotions? Psychological Review 35, 319–327. https://doi.org/10.1037/h0075969

Datta, S.R., 2019. Q&A: Understanding the composition of behavior. BMC Biology 17, 44. https://doi.org/10.1186/s12915-019-0663-3

Descartes, R., 1989. The Passions of the Soul (S. Voss, Trans.) (Original work published 1649). Hackett Publishing, Indianapolis, IN.

Dreyfus, G., Thompson, E., 2007. Asian perspectives: Indian theories of mind, in: Zelazo, P.D., Moscovitch, M., Thompson, E. (Eds.), The Cambridge Handbook of Consciousness. Cambridge University Press, pp. 89–114.

Dror, O.E., 2017. Deconstructing the “Two Factors”: The Historical Origins of the Schachter-Singer Theory of Emotions. Emotion Review 9, 7–16. https://doi.org/10.1177/1754073916639663

Duffy, E., 1941. An Explanation of “Emotional” Phenomena without the use of the Concept “Emotion.” The Journal of General Psychology 25, 283–293. https://doi.org/10.1080/00221309.1941.10544400

Duffy, E., 1934a. Is emotion a mere term of convenience? Psychological Review 41, 103–104. https://doi.org/10.1037/h0075951

Duffy, E., 1934b. Emotion: an example of the need for reorientation in psychology. Psychological Review 41, 184–198. https://doi.org/10.1037/h0074603

Dunlap, K., 1932. Are emotions teleological constructs? The American Journal of Psychology 44, 572–576. https://doi.org/10.2307/1415359

Durán, J.I., Fernández-Dols, J.-M., 2021. Do emotions result in their predicted facial expressions? A meta-analysis of studies on the co-occurrence of expression and emotion. Emotion 21, 1550–1569.

Edelman, G.M., 1989. The remembered present: a biological theory of consciousness. Basic Books.

Edelman, G.M., Gally, J.A., 2001. Degeneracy and complexity in biological systems. Proceedings of the National Academy of Sciences 98, 13763–13768.

Ekman, P., 1992. An argument for basic emotions. Cognition and Emotion 6, 169–200. https://doi.org/10.1080/02699939208411068

Ekman, P., Cordaro, D., 2011. What is Meant by Calling Emotions Basic. Emotion Review 3, 364–370. https://doi.org/10.1177/1754073911410740

Elfenbein, H.A., 2013. Nonverbal Dialects and Accents in Facial Expressions of Emotion. Emotion Review 5, 90–96. https://doi.org/10.1177/1754073912451332

Estes, W.K., 1956. The problem of inference from curves based on group data. Psychological bulletin 53, 134.

Eustace, N., 2019. Electric Signals: Emotional Currents, Cultural Conduits, Social Voltage and Power Generation in Eighteenth-Century Cultural Encounters. Emot. Hist. Cult. Soc. 3, 47–71. https://doi.org/10.1163/2208522X-02010039

Fehr, B., Russell, J.A., 1984. Concept of emotion viewed from a prototype perspective. Journal of experimental psychology: General 113, 464–486.

Finlay, B.L., Uchiyama, R., 2015. Developmental mechanisms channeling cortical evolution. Trends in neurosciences 38, 69–76.

Fontaine, J.R.J., Scherer, K.R., Roesch, E.B., Ellsworth, P.C., 2007. The World of Emotions is not Two-Dimensional. Psychol Sci 18, 1050–1057. https://doi.org/10.1111/j.1467-9280.2007.02024.x

Freddolino, P.L., Tavazoie, S., 2012. Beyond homeostasis: a predictive-dynamic framework for understanding cellular behavior. Annual review of cell and developmental biology 28, 363–384.

Frevert, U., Bailey, C., Eitler, P., Gammerl, B., Hitzer, B., Pernau, M., Scheer, M., Schmidt, A., Verheyen, N., 2014. Emotional Lexicons: Continuity and Change in the Vocabulary of Feeling 1700-2000, Emotions In History. Oxford University Press, Oxford. https://doi.org/10.1093/acprof:oso/9780199655731.001.0001

Friston, K., FitzGerald, T., Rigoli, F., Schwartenbeck, P., Pezzulo, G., 2017. Active Inference: A Process Theory. Neural Comput 29, 1–49. https://doi.org/10.1162/NECO_a_00912

Gallistel, C., 2013. The organization of action: A new synthesis. Psychology Press.

Gallistel, C., 2012. On the evils of group averaging. Behavioral Processes 90.

Gao, W., Lin, W., Grewen, K., Gilmore, J.H., 2017. Functional Connectivity of the Infant Human Brain: Plastic and Modifiable. Neuroscientist 23, 169–184. https://doi.org/10.1177/1073858416635986

Gee, H., 2018. Across the Bridge: Understanding the Origin of the Vertebrates. University of Chicago Press, Chicago IL.

Gelman, S.A., Roberts, S.O., 2017. How language shapes the cultural inheritance of categories. PNAS 114, 7900–7907. https://doi.org/10.1073/pnas.1621073114

Gendron, M., Barrett, L.F., 2018. Emotion Perception as Conceptual Synchrony. Emotion Review 10, 101–110. https://doi.org/10.1177/1754073917705717

Gendron, M., Barrett, L.F., 2009. Reconstructing the Past: A Century of Ideas About Emotion in Psychology. Emotion Review 1, 316–339. https://doi.org/10.1177/1754073909338877

Gendron, M., Crivelli, C., Barrett, L.F., 2018. Universality Reconsidered: Diversity in Making Meaning of Facial Expressions. Curr Dir Psychol Sci 27, 211–219. https://doi.org/10.1177/0963721417746794

Gendron, M., Hoemann, K., Crittenden, A.N., Mangola, S.M., Ruark, G.A., Barrett, L.F., 2020a. Emotion Perception in Hadza Hunter-Gatherers. Sci Rep 10, 3867. https://doi.org/10.1038/s41598-020-60257-2

Gendron, M., Mesquita, B., Barrett, L.F., 2020b. The Brain as a Cultural Artifact: Concepts, Actions, and Experiences within the Human Affective Niche, in: Worthman, C.M., Cummings, C.A., Kirmayer, L.J., Lemelson, R., Kitayama, S. (Eds.), Culture, Mind, and Brain: Emerging Concepts, Models, and Applications, Current Perspectives in Social and Behavioral Sciences. Cambridge University Press, Cambridge, pp. 188–222. https://doi.org/10.1017/9781108695374.010

Gershman, S.J., Blei, D.M., Niv, Y., 2010. Context, learning, and extinction. Psychol Rev 117, 197–209. https://doi.org/10.1037/a0017808

Gilmore, J.H., Knickmeyer, R.C., Gao, W., 2018. Imaging structural and functional brain development in early childhood. Nat Rev Neurosci 19, 123–137. https://doi.org/10.1038/nrn.2018.1

Gleiser, M., 2015. The island of knowledge: The limits of science and the search for meaning. Basic, New York.

Godfrey-Smith, P., 2017. Complexity revisited. Biology & Philosophy 32, 467–479. https://doi.org/10.1007/s10539-017-9569-z

Golinski, J., 2005. Making Natural Knowledge: Constructivism and the History of Science, with a new Preface. University of Chicago Press, Chicago, IL.

Grayson, D.S., Fair, D.A., 2017. Development of large-scale functional networks from birth to adulthood: A guide to the neuroimaging literature. NeuroImage 160, 15–31. https://doi.org/10.1016/j.neuroimage.2017.01.079

Gregory, R.L., 1980. Perceptions as hypotheses. Philos Trans R Soc Lond B Biol Sci 290, 181–197. https://doi.org/10.1098/rstb.1980.0090

Gross, C.T., Canteras, N.S., 2012. The many paths to fear. Nat Rev Neurosci 13, 651–8. https://doi.org/10.1038/nrn3301

Guillory, S.A., Bujarski, K.A., 2014. Exploring emotions using invasive methods: review of 60 years of human intracranial electrophysiology. Soc Cogn Affect Neurosci 9, 1880–9. https://doi.org/10.1093/scan/nsu002

Hacking, I., 1983. Representing and Intervening. Cambridge University Press, Cambridge.

Haldane, J.B.S., 1963. The truth about death. Journal of Genetics 58, 464.

Halgren, E., Walter, R.D., Cherlow, D.G., Crandall, P.H., 1978. Mental phenomena evoked by electrical stimulation of the human hippocampal formation and amygdala. Brain 101, 83–115.

Harlow, H.F., Stagner, R., 1933. Psychology of feelings and emotions. II. Theory of emotions. Psychological Review 40, 184–195. https://doi.org/10.1037/h0075696

Harlow, H.F., Stagner, R., 1932. Psychology of feelings and emotions: I. Theory of feelings. Psychological Review 39, 570–589. https://doi.org/10.1037/h0072961

Harmon-Jones, E., Peterson, C.K., 2009. Supine body position reduces neural response to anger evocation. Psychological Science 20, 1209–1210.

Harre, R., 1986. The social constructon of emotion. Blackwell.

Herry, C., Johansen, J.P., 2014. Encoding of fear learning and memory in distributed neuronal circuits. Nature neuroscience 17, 1644–1654.

Hoemann, K., Crittenden, A.N., Msafiri, S., Liu, Q., Li, C., Roberson, D., Ruark, G.A., Gendron, M., Feldman Barrett, L., 2019a. Context facilitates performance on a classic cross-cultural emotion perception task. Emotion 19, 1292–1313. https://doi.org/10.1037/emo0000501

Hoemann, K., Khan, Z., Feldman, M.J., Nielson, C., Devlin, M., Dy, J., Barrett, L.F., Wormwood, J.B., Quigley, K.S., 2020a. Context-aware experience sampling reveals the scale of variation in affective experience. Sci Rep 10, 12459. https://doi.org/10.1038/s41598-020-69180-y

Hoemann, K., Wu, R., LoBue, V., Oakes, L.M., Xu, F., Barrett, L.F., 2020b. Developing an Understanding of Emotion Categories: Lessons from Objects. Trends in Cognitive Sciences 24, 39–51. https://doi.org/10.1016/j.tics.2019.10.010

Hoemann, K., Xu, F., Barrett, L.F., 2019b. Emotion words, emotion concepts, and emotional development in children: A constructionist hypothesis. Developmental Psychology 55, 1830–1849. https://doi.org/10.1037/dev0000686

Hohwy, J., 2013. The predictive mind. OUP Oxford.

Hohwy, J., Seth, A., 2020. Predictive processing as a systematic basis for identifying the neural correlates of consciousness. PhiMiSci 1. https://doi.org/10.33735/phimisci.2020.II.64

Horikawa, T., Cowen, A.S., Keltner, D., Kamitani, Y., 2020. The Neural Representation of Visually Evoked Emotion Is High-Dimensional, Categorical, and Distributed across Transmodal Brain Regions. iScience 23, 101060. https://doi.org/10.1016/j.isci.2020.101060

Hunt, W.A., 1941. Recent developments in the field of emotion. Psychological Bulletin 38, 249–276. https://doi.org/10.1037/h0054615

Hutchinson, J.B., Barrett, L.F., 2019. The Power of Predictions: An Emerging Paradigm for Psychological Research. Curr Dir Psychol Sci 28, 280–291. https://doi.org/10.1177/0963721419831992

Izard, C.E., 1977. Human emotions, Emotions, personality, and psychotherapy. Plenum Press, New York.

Jack, R.E., Sun, W., Delis, I., Garrod, O.G., Schyns, P.G., 2016. Four not six: Revealing culturally common facial expressions of emotion. J Exp Psychol Gen 145, 708–30. https://doi.org/10.1037/xge0000162

James, W., 1998. The principles of psychology. Thoemmes Press (Original work published in 1890), Bristol.

James, W., 1994. The physical basis of emotion (Original work published 1894). Psychological Review 101, 205–210. https://doi.org/10.1037/0033-295X.101.2.205

James, W., 1884. What is an Emotion? Mind 9, 188–205. https://doi.org/10.1093/mind/os-IX.34.188

Jékely, G., Keijzer, F., Godfrey-Smith, P., 2015. An option space for early neural evolution. Philosophical Transactions of the Royal Society B: Biological Sciences 370, 20150181. https://doi.org/10.1098/rstb.2015.0181

Johnson-Laird, P.N., 1983. Mental models: Towards a cognitive science of language, inference, and consciousness. Harvard University Press.

Kant, I., 1929. Critique of Pure Reason (1781-1787), Trans. Kemp Smith. London: MacMillan.

Kaplan, H.S., Zimmer, M., 2020. Brain-wide representations of ongoing behavior: a universal principle? Current Opinion in Neurobiology 64, 60–69. https://doi.org/10.1016/j.conb.2020.02.008

Karmiloff-Smith, A., Klima, E., Bellugi, U., Grant, J., Baron-Cohen, S., 1995. Is there a social module? Language, face processing, and theory of mind in individuals with williams syndrome. Journal of cognitive neuroscience 7, 196–208. https://doi.org/10.1162/jocn.1995.7.2.196

Kassam, K.S., Markey, A.R., Cherkassky, V.L., Loewenstein, G., Just, M.A., 2013. Identifying Emotions on the Basis of Neural Activation. Plos One 8. https://doi.org/10.1371/journal.pone.0066032

Katsumi, Y., Zhang, J., Chen, D., Kamona, N., Bunce, J. G., Hutchinson, J. B., Yarossi, M., Tunik, E., Dickerson, B. C., Quigley, K. S. & Barrett, L. F. (2023). Correspondence of functional connectivity gradients across human isocortex, cerebellum and hippocampus. *Communications Biology*, 6, 401.

Katsumi, Y., Theriault, J. E., Quigley, K. S., & Barrett, L. F. (2022). Allostasis as a core feature of hierarchical gradients in the human brain. *Network Neuroscience, 6*, 1010-1031.

Keck, T., Keller, G.B., Jacobsen, R.I., Eysel, U.T., Bonhoeffer, T., Hübener, M., 2013. Synaptic Scaling and Homeostatic Plasticity in the Mouse Visual Cortex In Vivo. Neuron 80, 327–334. https://doi.org/10.1016/j.neuron.2013.08.018

Khalaf, A., Nabian, M., Fan, M., Yin, Y., Wormwood, J., Siegel, E., Quigley, K.S., Barrett, L.F., Akcakaya, M., Chou, C.-A., Ostadabbas, S., 2020. Analysis of multimodal physiological signals within and between individuals to predict psychological challenge vs. threat. Expert Systems with Applications 140, 112890. https://doi.org/10.1016/j.eswa.2019.112890

Kleckner, I.R., Zhang, J., Touroutoglou, A., Chanes, L., Xia, C., Simmons, W.K., Quigley, K.S., Dickerson, B.C., Barrett, L.F., 2017. Evidence for a large-scale brain system supporting allostasis and interoception in humans. Nat Hum Behav 1, 0069. https://doi.org/10.1038/s41562-017-0069

Kragel, P.A., Labar, K.S., 2015. Multivariate neural biomarkers of emotional states are categorically distinct. Soc Cogn Affect Neur 10, 1437–1448. https://doi.org/10.1093/scan/nsv032

Kragel, P.A., LaBar, K.S., 2013. Multivariate pattern classification reveals autonomic and experiential representations of discrete emotions. Emotion 13, 681–90. https://doi.org/10.1037/a0031820

Kuhn, T.S., 1962. The Structure of Scientific Revolutions. University of Chicago Press, Chicago, IL.

Kuppens, P., &. Tong, E.M.W., 2010. An Appraisal Account of Individual Differences in Emotional Experience. Social and Personality Psychology Compass 4, 1138–1150.

Kuppens, P., Van Mechelen, I., Rijmen, F., 2008. Toward disentangling sources of individual differences in appraisal and anger. Journal of Personality 76, 969–1000.

Kuppens, P., Van Mechelen, I., Smits, D.J.M., De Boeck, P., Ceulemans, E., 2007. Individual differences in patterns of appraisal and anger experience. Cognition Emotion 21, 689–713. https://doi.org/10.1080/02699930600859219

Lakoff, G., 2016. Language and Emotion. Emotion Review 8, 269–273. https://doi.org/10.1177/1754073915595097

Laland, K.N., Uller, T., Feldman, M.W., Sterelny, K., Müller, G.B., Moczek, A., Jablonka, E., Odling-Smee, J., 2015. The extended evolutionary synthesis: its structure, assumptions and predictions. Proceedings of the Royal Society B: Biological Sciences 282, 20151019. https://doi.org/10.1098/rspb.2015.1019

Landis, C., 1924. Studies of Emotional Reactions. II. General Behavior and Facial Expression. Journal of Comparative Psychology 4, 447–510.

Lazarus, R.S., 2001. Relational meaning and discrete emotions., in: Appraisal Processes in Emotion: Theory, Methods, Research., Series in Affective Science. Oxford University Press, New York, NY, US, pp. 37–67.

Lazarus, R.S., 1991. Emotion and adaptation. Oxford University Press, New York.

Le Mau, T., Hoemann, K., Lyons, S.H., Fugate, J.M.B., Brown, E.N., Gendron, M., Barrett, L.F., 2021. Professional actors demonstrate variability, not stereotypical expressions, when portraying emotional states in photographs. Nat Commun 12, 5037. https://doi.org/10.1038/s41467-021-25352-6

Lebois, L.A.M., Wilson-Mendenhall, C.D., Simmons, W.K., Barrett, L.F., Barsalou, L.W., 2020. Learning situated emotions. Neuropsychologia, The Neural Basis of Emotion 145, 106637. https://doi.org/10.1016/j.neuropsychologia.2018.01.008

Lebrecht, S., Bar, M., Barrett, L.F., Tarr, M.J., 2012. Micro-valences: perceiving affective valence in everyday objects. Frontiers in psychology 3, 107. https://doi.org/10.3389/fpsyg.2012.00107

LeDoux, J.E., 2000. Emotion circuits in the brain. Annual review of neuroscience 23, 155–84. https://doi.org/10.1146/annurev.neuro.23.1.155

Levenson, R.W., 2011. Basic Emotion Questions. Emotion Review 3, 379–386. https://doi.org/10.1177/1754073911410743

Levinthal, D.J., Strick, P.L., 2012. The Motor Cortex Communicates with the Kidney. Journal of Neuroscience 32, 6726–6731. https://doi.org/10.1523/JNEUROSCI.0406-12.2012

Lewontin, 2000. The triple helix: Gene, organism and environment, R.C. Harvard University Press, Cambridge MA.

Leys, R., 2017. The ascent of affect. University of Chicago Press.

Liang, M., Mouraux, A., Hu, L., Iannetti, G.D., 2013. Primary sensory cortices contain distinguishable spatial patterns of activity for each sense. Nat Commun 4, 1979. https://doi.org/10.1038/ncomms2979

Lindquist, K.A., 2013. Emotions Emerge from More Basic Psychological Ingredients: A Modern Psychological Constructionist Model. Emotion Review 5, 356–368. https://doi.org/10.1177/1754073913489750

Lindquist, K.A., Wager, T.D., Kober, H., Bliss-Moreau, E., Barrett, L.F., 2012. The brain basis of emotion: A meta-analytic review. Behav Brain Sci 35, 121–143. https://doi.org/10.1017/S0140525X11000446

Lochmann, T., Deneve, S., 2011. Neural processing as causal inference. Curr Opin Neurobiol 21, 774–781. https://doi.org/10.1016/j.conb.2011.05.018

Lyon, P., 2015. The cognitive cell: bacterial behavior reconsidered. Front. Microbiol. 6. https://doi.org/10.3389/fmicb.2015.00264

MacIver, M.A., Finlay, B.L., 2021. The neuroecology of the water-to-land transition and the evolution of the vertebrate brain. Philosophical Transactions of the Royal Society B-Biological Sciences 337, 20200523.

Malebranche, N., 1997. The search after truth (Original work published in French 1674-75). Cambridge University Press, Cambridge.

Mandler, G., 1990. William James and the construction of emotion. Psychological Science 1, 179–180. https://doi.org/10.1111/j.1467-9280.1990.tb00193.x

Mandler, G., 1984. Mind and Body: Psychology of Emotion and Stress. Wiley, New York.

Marder, E., Taylor, A.L., 2011. Multiple models to capture the variability in biological neurons and networks. Nature Neuroscience 14, 133–138.

Mareschal, D., Johnson, M.H., Sirois, S., Spratling, M., Thomas, M.S., Westermann, G., 2007. Neuroconstructivism-I: How the Brain Constructs Cognition. Oxford University Press.

Mareschal, D., Quinn, P.C., Lea, S.E., 2010. The making of human concepts. Oxford University Press, USA.

Matsumoto, D., 1990. Cultural similarities and differences in display rules. Motiv Emot 14, 195–214. https://doi.org/10.1007/BF00995569

Mayr, E., 2004. What makes biology unique?: considerations on the autonomy of a scientific discipline. Cambridge University Press.

McIntosh, A.R., 2004. Contexts and catalysts: a resolution of the localization and integration of function in the brain. Neuroinformatics 2, 175–82. https://doi.org/10.1385/NI:2:2:175

McNamee, D., Wolpert, D.M., 2019. Internal Models in Biological Control. Annual Review of Control, Robotics, and Autonomous Systems 2, 339–364. https://doi.org/10.1146/annurev-control-060117-105206

Merabet, L.B., Maguire, D., Warde, A., Alterescu, K., Stickgold, R., Pascual-Leone, A., 2004. Visual Hallucinations During Prolonged Blindfolding in Sighted Subjects: Journal of Neuro-Ophthalmology 24, 109–113. https://doi.org/10.1097/00041327-200406000-00003

Mesquita, B., 2022. Between us: How cultures create emotions. Norton, New York NY.

Mesquita, B., Frijda, N.H., 1992. Cultural variations in emotions: a review. Psychological bulletin 112, 179–204.

Mihov, Y., Kendrick, K.M., Becker, B., Zschernack, J., Reich, H., Maier, W., Keysers, C., Hurlemann, R., 2013. Mirroring fear in the absence of a functional amygdala. Biological psychiatry 73, e9-11. https://doi.org/10.1016/j.biopsych.2012.10.029

Motta, S.C., Goto, M., Gouveia, F.V., Baldo, M.V., Canteras, N.S., Swanson, L.W., 2009. Dissecting the brain's fear system reveals the hypothalamus is critical for responding in subordinate conspecific intruders. Proceedings of the National Academy of Sciences 106, 4870–4875.

Murphy, G.L., 2002. The Big Book of Concepts. MIT Press, Cambridge, MA.

Neisser, U., 1967. Cognitive psychology. Appleton-Century-Crofts, New York.

Nezlek, J.B., Vansteelandt, K., Van Mechelen, I., Kuppens, P., 2008. Appraisal-emotion relationships in daily life. Emotion 8, 145–50. https://doi.org/10.1037/1528-3542.8.1.145

Ngai, S., 2007. Ugly Feelings. Harvard University Press, Cambridge, MA.

Nguyen, T., Schleihauf, H., Kayhan, E., Matthes, D., Vrtička, P., Hoehl, S., 2021. Neural synchrony in mother–child conversation: Exploring the role of conversation patterns. Social Cognitive and Affective Neuroscience 16, 93–102. https://doi.org/10.1093/scan/nsaa079

Nozawa, T., Sakaki, K., Ikeda, S., Jeong, H., Yamazaki, S., Kawata, K.H. dos S., Kawata, N.Y. dos S., Sasaki, Y., Kulason, K., Hirano, K., Miyake, Y., Kawashima, R., 2019. Prior physical synchrony enhances rapport and inter-brain synchronization during subsequent educational communication. Sci Rep 9, 12747. https://doi.org/10.1038/s41598-019-49257-z

Oakes, L.M., Rakison, D.H., 2019. Developmental Cascades: Building the Infant Mind. Oxford University Press, New York. https://doi.org/10.1093/oso/9780195391893.001.0001

Obrist, P.A., 1981. Cardiovascular psychophysiology: A perspective. Plenum, New York.

Obrist, P.A., Webb, R.A., Sutterer, J.R., Howard, J.L., 1970. The Cardiac-Somatic Relationship: Some Reformulations. Psychophysiology 6, 569–587. https://doi.org/10.1111/j.1469-8986.1970.tb02246.x

Oreskes, N., 2019. Why trust science. Princeton University Press.

Osgood, C.E., Suci, G.J., Tannenbaum, P.H., 1957. The measurement of meaning. University of Illinois press.

Owens, A.P., Allen, M., Ondobaka, S., Friston, K.J., 2018. Interoceptive inference: From computational neuroscience to clinic. Neuroscience & Biobehavioral Reviews 90, 174–183. https://doi.org/10.1016/j.neubiorev.2018.04.017

Panksepp, J., 1998. Affective neuroscience: The foundations of human and animal emotions. Oxford University Press, New York.

Pavlenko, A., 2014. The bilingual mind: And what it tells us about language and thought. Cambridge University Press.

Petzschner, F.H., Garfinkel, S.N., Paulus, M.P., Koch, C., Khalsa, S.S., 2021. Computational Models of Interoception and Body Regulation. Trends in Neurosciences, Special Issue: The Neuroscience of Interoception 44, 63–76. https://doi.org/10.1016/j.tins.2020.09.012

Pezzulo, G., Rigoli, F., Friston, K., 2015. Active Inference, homeostatic regulation and adaptive behavioural control. Progress in neurobiology 134, 17–35. https://doi.org/10.1016/j.pneurobio.2015.09.001

Pezzulo, G., Zorzi, M., Corbetta, M., 2021. The secret life of predictive brains: what's spontaneous activity for? Trends in Cognitive Sciences 25, 730–743. https://doi.org/10.1016/j.tics.2021.05.007

Plate, R.C., Wood, A., Woodard, K., Pollak, S.D., 2019. Probabilistic learning of emotion categories. Journal of Experimental Psychology: General 148, 1814.

Plate, R.C., Woodard, K., Pollak, S.D., 2022. Statistical learning in an emotional world, in: Dukes, D., Samson, A.D., Walle, E.A. (Eds.), The Oxford Handbook of Emotional Development. Oxford University Press.

Pontzer, H., 2015. Energy expenditure in humans and other primates: a new synthesis. Annual Review of Anthropology 44, 169–187. https://doi.org/10.1146/annurev-anthro-102214-013925

Quigley, K.S., Kanoski, S., Grill, W.M., Barrett, L.F., Tsakiris, M., 2021. Functions of Interoception: From Energy Regulation to Experience of the Self. Trends in Neurosciences 44, 29–38. https://doi.org/10.1016/j.tins.2020.09.008

Radulescu, A., Shin, Y.S., Niv, Y., 2021. Human Representation Learning. Annual Review of Neuroscience 44, 253–273. https://doi.org/10.1146/annurev-neuro-092920-120559

Raz, G., Touroutoglou, A., Wilson-Mendenhall, C., Gilam, G., Lin, T., Gonen, T., Jacob, Y., Atzil, S., Admon, R., Bleich-Cohen, M., Maron-Katz, A., Hendler, T., Barrett, L.F.,

2016. Functional connectivity dynamics during film viewing reveal common networks for different emotional experiences. Cogn Affect Behav Neurosci 16, 709–723. https://doi.org/10.3758/s13415-016-0425-4

Reddy, W.M., 1997. Against Constructionism: The Historical Ethnography of Emotions. Current Anthropology 38, 327–351. https://doi.org/10.1086/204622

Reynolds, S.M., Berridge, K.C., 2008. Emotional environments retune the valence of appetitive versus fearful functions in nucleus accumbens. Nature Neuroscience 11, 423–5. https://doi.org/10.1038/nn2061

Richerson, P.J., Boyd, R., 2008. Not by genes alone: How culture transformed human evolution. University of Chicago Press, Chicago, IL.

Rigotti, M., Barak, O., Warden, M.R., Wang, X.-J., Daw, N.D., Miller, E.K., Fusi, S., 2013. The importance of mixed selectivity in complex cognitive tasks. Nature 497, 585–590.

Roseman, I.J., 2011. Emotional behaviors, emotivational goals, emotion strategies: Multiple levels of organization integrate variable and consistent responses. Emotion Review 3, 1–10.

Russell, J.A., 2003. Core affect and the psychological construction of emotion. Psychological review 110, 145–72.

Russell, J.A., 1991a. Culture and the categorization of emotions. Psychological Bulletin 110, 426–450. https://doi.org/10.1037/0033-2909.110.3.426

Russell, J.A., 1991b. In defense of a prototype approach to emotion concepts. Journal of personality and social psychology 60, 37–47.

Saarimaki, H., Gotsopoulos, A., Jaaskelainen, I.P., Lampinen, J., Vuilleumier, P., Hari, R., Sams, M., Nummenmaa, L., 2016. Discrete Neural Signatures of Basic Emotions. Cereb Cortex 26, 2563–2573. https://doi.org/10.1093/cercor/bhv086

Satpute, A.B., Kang, J., Bickart, K.C., Yardley, H., Wager, T.D., Barrett, L.F., 2015. Involvement of Sensory Regions in Affective Experience: A Meta-Analysis. Front. Psychol. 6. https://doi.org/10.3389/fpsyg.2015.01860

Scarantino, A., 2018. Are LeDoux’s survival circuits basic emotions under a different name? Current Opinion in Behavioral Sciences 24, 75–82. https://doi.org/10.1016/j.cobeha.2018.06.001

Scarantino, A., Griffiths, P., 2011. Don't give up on basic emotions. Emotion Review 3, 444–454.

Schachter, S., 1959. The psychology of affiliation: Experimental studies of the sources of gregariousness, The psychology of affiliation: Experimental studies of the sources of gregariousness. Stanford Univer. Press, Palo Alto, CA, US.

Schachter, S., Singer, J.E., 1962. Cognitive, social, and physiological determinant of emotional state. Psychological Reviews 69, 379–399.

Scherer, K.R., 2001. Appraisal considered as a process of multilevel sequential checking., in: Appraisal Processes in Emotion: Theory, Methods, Research., Series in Affective Science. Oxford University Press, New York, NY, US, pp. 92–120.

Schulkin, J., Sterling, P., 2019. Allostasis: A Brain-Centered, Predictive Mode of Physiological Regulation. Trends in Neurosciences 42, 740–752. https://doi.org/10.1016/j.tins.2019.07.010

Sennesh, E., Theriault, J., Brooks, D., van de Meent, J.-W., Barrett, L.F., Quigley, K.S., 2021. Interoception as modeling, allostasis as control. Biological Psychology 108242.

Seth, A., Friston, K., 2016. Active interoceptive inference and the emotional brain. Philosophical Transactions of the Royal Society B-Biological Sciences 371(1708). https://doi.org/10.1098/rstb.2016.0007

Seth, A.K., Tsakiris, M., 2018. Being a Beast Machine: The Somatic Basis of Selfhood. Trends in Cognitive Sciences 22, 969–981. https://doi.org/10.1016/j.tics.2018.08.008

Shaffer, C., Westlin, C., Quigley, K. S., Whitfield-Gabrieli, S., & Barrett, L. F. (2022). Allostasis, action and affect in depression: Insights from the theory of constructed emotion. *Annual Review of Clinical Psychology*, 18, 553-580.

Shariff, A.F., Tracy, J.L., 2011. What are emotion expressions for? Current Directions in Psychological Science 20, 395–399. https://doi.org/10.1177/0963721411424739

Shaver, P., Schwartz, J., Kirson, D., O'connor, C., 1987. Emotion knowledge: further exploration of a prototype approach. Journal of personality and social psychology 52, 1061–1068.

Sherman, M., 1927a. The differentiation of emotional responses in infants. Journal of Comparative Psychology 7, 335–351. https://doi.org/10.1037/h0069981

Sherman, M., 1927b. The differentiation of emotional responses in infants. I. Judgments of emotional responses from motion picture views and from actual observation. Journal of Comparative Psychology 7, 265–284. https://doi.org/10.1037/h0073204

Sherwood, C.C., Bauernfeind, A.L., Bianchi, S., Raghanti, M.A., Hof, P.R., 2012. Human brain evolution writ large and small. Prog Brain Res 195, 237–54. https://doi.org/10.1016/B978-0-444-53860-4.00011-8

Sherwood, C.C., Bauernfeind, A.L., Verendeev, A., Raghanti, M.A., Hof, P.R., 2017. Evolutionary Specializations of Human Brain Microstructure, in: Evolution of Nervous Systems. pp. 121–139. https://doi.org/10.1016/b978-0-12-804042-3.00127-5

Siegel, E.H., Sands, M.K., Van den Noortgate, W., Condon, P., Chang, Y., Dy, J., Quigley, K.S., Barrett, L.F., 2018. Emotion fingerprints or emotion populations? A meta-analytic investigation of autonomic features of emotion categories. Psychological Bulletin 144, 343–393. https://doi.org/10.1037/bul0000128

Simpson, S.J., Raubenheimer, D., 2012. The Nature of Nutrition: A Unifying Framework from Animal Adaptation to Human Obesity. Princeton University Press.

Sinaceur, M., Tiedens, L.Z., 2006. Get mad and get more than even: When and why anger expression is effective in negotiations. Journal of Experimental Social Psychology 42, 314–322.

Singh, A., Westlin, C., Eisenbarth, E., Losin, E.A.R., J. R. Andrews-Hanna, Wager, T., Satpute, A.B., Lisa Feldman Barrett, Dana H Brooks, Deniz Erdogmus, 2021. Variation is the Norm: Brain State Dynamics Evoked By Emotional Video Clips. Presented at the 43rd Annual International Conference of the IEEE Engineering in Medicine & Biology Society.

Smith, T.W., 2015. The Book of Human Emotions: An Encyclopedia of Feeling from Anger to. Wellcome.

Sokolov, E.N., 1963. Higher Nervous Functions: The Orienting Reflex. Annual Review of Physiology 25, 545–580. https://doi.org/10.1146/annurev.ph.25.030163.002553

Spinoza, B., 1927. Ethics (S. Shirley, Trans.) (Original work published 1677). Washburn, Indianapolis, IN.

Spivey, M.J., 2007. The continuity of mind. Oxford University Press, New York.

Srinivasan, R., Martinez, A.M., 2021. Cross-Cultural and Cultural-Specific Production and Perception of Facial Expressions of Emotion in the Wild. IEEE Transactions on Affective Computing 12, 707–721. https://doi.org/10.1109/TAFFC.2018.2887267

Stemmler, G., Aue, T., Wacker, J., 2007. Anger and fear: Separable effects of emotion and motivational direction on somatovisceral responses. International journal of psychophysiology : official journal of the International Organization of Psychophysiology 66, 141–53. https://doi.org/10.1016/j.ijpsycho.2007.03.019

Stephan, K.E., Manjaly, Z.M., Mathys, C.D., Weber, L.A.E., Paliwal, S., Gard, T., Tittgemeyer, M., Fleming, S.M., Haker, H., Seth, A.K., Petzschner, F.H., 2016. Allostatic Self-efficacy: A Metacognitive Theory of Dyshomeostasis-Induced Fatigue and Depression. Front Hum Neurosci 10. https://doi.org/10.3389/fnhum.2016.00550

Stephens, C.L., Christie, I.C., Friedman, B.H., 2010. Autonomic specificity of basic emotions: evidence from pattern classification and cluster analysis. Biological psychology 84, 463–73. https://doi.org/10.1016/j.biopsycho.2010.03.014

Sterling, P., 2012. Allostasis: a model of predictive regulation. Physiology & behavior 106, 5–15.

Sterling, P., Laughlin, S., 2015. Principles of Neural Design. MIT Press, Cambridge, MA.

Stokes, M.G., Kusunoki, M., Sigala, N., Nili, H., Gaffan, D., Duncan, J., 2013. Dynamic coding for cognitive control in prefrontal cortex. Neuron 78, 364–75. https://doi.org/10.1016/j.neuron.2013.01.039

Striedter, G., 2005. Principles of Brain Evolution (Sinauer, Sunderland, MA).

Striedter, G.F., Northcutt, R.G., 2020. Brains Through Time : A Natural History of Vertebrates. Oxford University Press, New York, NY, United States of America.

Theriault, J.E., Shaffer, C., Dienel, G.A., Sander, C.Y., Hooker, J.M., Dickerson, B.C., Barrett, L.F., Quigley, K., 2021a. Aerobic glycolysis, the efficiency tradeoff hypothesis, and the biological basis of neuroimaging: A solution to a metabolic mystery at the heart of neuroscience. (preprint). PsyArXiv. https://doi.org/10.31234/osf.io/pkzr8

Theriault, J.E., Young, L., Barrett, L.F., 2021b. The sense of should: A biologically-based framework for modeling social pressure. Physics of Life Reviews 36, 100–136. https://doi.org/10.1016/j.plrev.2020.01.004

Tolman, E.C., 1948. Cognitive maps in rats and men. Psychological Review 55, 189–208. https://doi.org/10.1037/h0061626

Tononi, G., Sporns, O., Edelman, G.M., 1999. Measures of degeneracy and redundancy in biological networks. Proceedings of the National Academy of Sciences 96, 3257–3262.

Tononi, G., Srinivasan, R., Russell, D.P., Edelman, G.M., 1998. Investigating neural correlates of conscious perception by frequency-tagged neuromagnetic responses. Proceedings of the National Academy of Sciences 95, 3198–3203.

Tovote, P., Fadok, J.P., Lüthi, A., 2015. Neuronal circuits for fear and anxiety. Nature Reviews Neuroscience 16, 317–331.

Tracy, J.L., Randles, D., 2011. Four Models of Basic Emotions: A Review of Ekman and Cordaro, Izard, Levenson, and Panksepp and Watt. Emotion Review 3, 397–405. https://doi.org/10.1177/1754073911410747

van den Heuvel, M.P., Scholtens, L.H., Turk, E., Mantini, D., Vanduffel, W., Barrett, L.F., 2016. Multimodal analysis of cortical chemoarchitecture and macroscale fMRI resting-state functional connectivity. Hum Brain Mapp 37, 3103–3113. https://doi.org/10.1002/hbm.23229

Van Kleef, G.A., Côté, S., 2007. Expressing anger in conflict: when it helps and when it hurts. Journal of Applied Psychology 92, 1557.

Van Zomeren, M., Spears, R., Fischer, A.H., Leach, C.W., 2004. Put your money where your mouth is! Explaining collective action tendencies through group-based anger and group efficacy. Journal of personality and social psychology 87, 649–664.

Vazdarjanova, A., McGaugh, J.L., 1999. Basolateral amygdala is involved in modulating consolidation of memory for classical fear conditioning. The journal of neuroscience 19, 6615–6622.

Vigliocco, G., Meteyard, L., Andrews, M., Kousta, S., 2009. Toward a theory of semantic representation. Language and Cognition 1, 219–247. https://doi.org/10.1515/LANGCOG.2009.011

Voorspoels, W., Vanpaemel, W., Storms, G., 2011. A formal ideal-based account of typicality. Psychonomic bulletin & review 18, 1006–1014.

Vouloumanos, A., Waxman, S.R., 2014. Listen up! Speech is for thinking during infancy. Trends in cognitive sciences 18, 642–646.

Wager, T.D., Kang, J., Johnson, T.D., Nichols, T.E., Satpute, A.B., Barrett, L.F., 2015. A Bayesian Model of Category-Specific Emotional Brain Responses. PLoS Comput Biol 11, e1004066. https://doi.org/10.1371/journal.pcbi.1004066

Waxman, S.R., Gelman, S.A., 2010. Different kinds of concepts and different kinds of words: What words do for human cognition. The making of human concepts 101–130.

Westermann, G., Mareschal, D., Johnson, M.H., Sirois, S., Spratling, M.W., Thomas, M.S.C., 2007. Neuroconstructivism. Developmental Science 10, 75–83.

Whitacre, J., Bender, A., 2010. Degeneracy: a design principle for achieving robustness and evolvability. Journal of Theoretical Biology 263, 143–153.

Whitacre, J.M., 2010. Degeneracy: a link between evolvability, robustness and complexity in biological systems. Theor Biol Med Model 7, 1–17.

Wilson-Mendenhall, C.D., Barrett, L.F., Barsalou, L.W., 2015. Variety in emotional life: within-category typicality of emotional experiences is associated with neural activity in large-scale brain networks. Social Cognitive and Affective Neuroscience 10, 62–71. https://doi.org/10.1093/scan/nsu037

Wilson-Mendenhall, C.D., Barrett, L.F., Barsalou, L.W., 2013. Neural Evidence That Human Emotions Share Core Affective Properties. Psychol Sci 24, 947–956. https://doi.org/10.1177/0956797612464242

Wilson-Mendenhall, C.D., Barrett, L.F., Simmons, W.K., Barsalou, L.W., 2011. Grounding emotion in situated conceptualization. Neuropsychologia 49, 1105–1127. https://doi.org/10.1016/j.neuropsychologia.2010.12.032

Winning, J., Bechtel, W., 2018. Rethinking Causality in Biological and Neural Mechanisms: Constraints and Control. Minds & Machines 28, 287–310. https://doi.org/10.1007/s11023-018-9458-5

Woodard, K., Plate, R.C., Morningstar, M., Wood, A., Pollak, S.D., 2021a. Categorization of Vocal Emotion Cues Depends on Distributions of Input. Affec Sci 2, 301–310. https://doi.org/10.1007/s42761-021-00038-w

Woodard, K., Plate, R.C., Pollak, S.D., 2021b. Children track probabilistic distributions of facial cues across individuals. Journal of Experimental Psychology: General.

Workman, A.D., Charvet, C.J., Clancy, B., Darlington, R.B., Finlay, B.L., 2013. Modeling transformations of neurodevelopmental sequences across mammalian species. The

Journal of neuroscience : the official journal of the Society for Neuroscience 33, 7368–83. https://doi.org/10.1523/JNEUROSCI.5746-12.2013

Wundt, W., 1998. Outlines of psychology (C.H. Judd, tran.). Thoemmes Press. (Original work published 1897), Bristol, UK.

Xu, F., Kushnir, T., 2013. Infants are rational constructivist learners. Current Directions in Psychological Science 22, 28–32.

Zhang, J., Abiose, O., Katsumi, Y., Touroutoglou, A., Dickerson, B.C., Barrett, L.F., 2019. Intrinsic Functional Connectivity is Organized as Three Interdependent Gradients. Sci Rep 9, 15976. https://doi.org/10.1038/s41598-019-51793-7

Zhang, J., Scholtens, L.H., Wei, Y., van den Heuvel, M.P., Chanes, L., Barrett, L.F., 2020. Topography Impacts Topology: Anatomically Central Areas Exhibit a "High-Level Connector" Profile in the Human Cortex. Cerebral Cortex 30, 1357–1365. https://doi.org/10.1093/cercor/bhz171

Zhou, F., Zhao, W., Qi, Z., Geng, Y., Yao, S., Kendrick, K.M., Wager, T.D., Becker, B., 2021. A distributed fMRI-based signature for the subjective experience of fear. Nat Commun 12, 6643. https://doi.org/10.1038/s41467-021-26977-3

Zuo, X.-N., He, Y., Betzel, R.F., Colcombe, S., Sporns, O., Milham, M.P., 2017. Human Connectomics across the Life Span. Trends in Cognitive Sciences 21, 32–45. https://doi.org/10.1016/j.tics.2016.10.005

Table 1

Comparing constructionist and typological perspectives on emotion

	Constructionist Perspective	Typological Perspective
Instance of Emotion	First-person phenomenon; exists in relation to a perceiver	Third-person phenomenon; exists independent of a perceiver
Emotion Category	A prototype category of instances with a family resemblance to the most representative or most typical instance (Russell, 2003); or, a population of variable, situated instances; prototypes are abstractions (Barrett, 2006, 2017a,b).	A natural kind category of instances with necessary and sufficient features (e.g., Panksepp, 1998); or a prototype category (e.g., Cowen & Keltner, 2022; Ekman, 1992; Shaver et al., 1987)
Concept	Situated and variable	Static across situations and people.
Variation	Intrinsic to emotion	The result of processes that modify emotion, such as learning, display rules, regulation, or other processes
Physical Features (e.g., vocalizations, movements, physiological changes, neural firing)	Relational meaning	Inherent emotional meanings that are genetically inherited and biologically prepared (basic emotion); or inherent appraisal meanings (causal appraisal views).
Evolutionary Approach	Extended Evolutionary Synthesis	Modern Synthesis